



PROCEEDINGS

International Congress on Rural Health 2015

&

IV International Conference Ragusa SHWA 2015

*Safety, Health and Welfare in Agriculture
Agro-food and Forestry Systems*

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The NEW Lodi Declaration on Rural Health

Adopted by the International Congress
on Rural Health (ICRH)

and the 4th International Conference
Safety Health Welfare in Agriculture Agro-Food
and Forestry Systems (Ragusa SHWA)

Whereas more than 50% of the world's population live in rural areas, with limited or no access to primary health care, basic occupational health care, clean water and sanitation,

Whereas unsustainable and unhealthy agricultural practices have influence on the rural population, with potential severe influence on the environment, wildlife, and urban population, through contaminated soil, water and food,

Whereas structural system-related determinants accompanied by unsafe work behaviours causes occupational and work-related diseases and injuries, disabilities, premature deaths, loss of income, as well as human suffering and poverty in rural areas,

Whereas children and women working in agriculture are especially vulnerable to occupational and environmental risks, in addition to consequences arising from the unavailability of basic health service and inadequate housing, in particular from household fuel combustion,

Whereas international, national and local actions, although significant and honourable, have not been able to respond successfully to all the challenges put before them,

Underlining that the achievement of the highest possible level of health for all people is impossible without improving the health of the rural population, and this is impossible without the involvement of the public sector as a whole,

Taking into consideration the Declaration of the International Conference on Primary Health Care, Alma-Ata, USSR, 1978, the *Global Strategy on Occupational Health for All* adopted by the World Health Assembly with Resolution 49.12 from 1996 and the *Global Strategy on Occupational Safety and Health* adopted by the International Labour Conference in 2003, *the Safety and Health in Agriculture Convention, 2001 (No. 184)* of the International Labour Organisation.

Recalling the outcomes of previous international deliberations on occupational health in agriculture and rural health, such as the *Declaration of the First International Congress on Rural Health in the Mediterranean and Balkan Countries* (Bari, Italy, 2002), the *Agenda on Rural Health* (Loni, India, 2002), the *Declaration on Occupational and Environmental Rural Health* (Belgrade, Serbia, 2004), the *Lodi Declaration on Healthy Villages* (Lodi, Italy, 2006), the *Cartagena Declaration on Rural Health in Latin America* (Cartagena de Indias, Colombia, 2009), and the *Goa Declaration for Health in the Global Village* (Panaji, Goa, India, 2012),

Recalling the continuing appeal of spiritual and secular leaders and of scholars and scientists worldwide to a responsible stewardship of the Planet, to a shared and sustainable access to its natural and limited resources, to their preservation for future generations,

We, the 250 participants from 52 countries from all continents who took part in the International Congress on Rural Health and 4th Ragusa SHWA, held here in Lodi, Italy, from September 8th to September 11th, 2015, discussed the challenges to providing adequate occupational and environmental health, food safety, public health and medical services in rural areas, and

WE DECLARE THAT:

1. We will commit ourselves to help solving occupational, environmental and public health problems and inadequacies in access to health care in rural areas, in the frame of the WHO global strategy on people centred and integrated health service;
2. We will advocate for the elimination of child labour in rural and remote areas, recognition of informal and migrant agricultural workers, and abolishment of modern slavery;
3. We call for national and international organizations, as well as individuals to work on the improvement of the scope and coverage

of primary health care to address better the needs of rural communities inclusive needs related to health and safety at work such as agrochemical use, heavy physical work, accidents, heat stress, dehydration and kidney injuries, cancer due to solar radiation, biological risk factors and zoonoses;

4. We will work towards providing higher access of workers to occupational health care with the creation of basic occupational health services in rural areas wherever necessary,
5. We recognize the need for addressing occupational, environmental and public health risks in rural areas by working together with all of the stakeholders, governments, public sector a while, and industry, as well as the ministries of health, environment, labour, agriculture and other state agencies, private enterprises and workers' organizations;
6. We underline the significance of local, regional, national and international initiatives to protect and promote the health of the rural population;
7. We encourage the following organizations: The European Rural and Isolated Practitioners Association (EURIPA), The International Association on Rural Medicine and Health (IARM), the International Commission on Occupational Health (ICOH), the WONCA Working Party on Rural Practice, as well as the organizations of farmers, agricultural workers, agricultural industry, and the relevant non-governmental organizations and networks, to take action to support and promote the development of Rural Health programmes;
8. We will dedicate a significant part of our scientific and professional efforts to create useful, accessible, simple and low-cost tools for occupational, indoor and environmental risk assessment, communication and management;
9. We call upon the governmental agencies and local authorities to ensure equal and proper access of people in villages, to information

on public and occupational health and the environment, stimulate social and environmental justice, as well as to provide means for empowerment of rural populations to protect and promote their health, and to improve their working and living conditions. Access to health care should be treated as a basic human right. Use of e-health and telemedicine should be promoted in rural area;

10. We congratulate our colleagues which have been working on opening reference centres at the local, national and international level for providing expertise and support to the rural population;
11. We call for the creation of interdisciplinary teams of experts from the field of human and veterinary medicine, public, occupational, and environmental health, health promotion, food safety, chemical safety, agricultural, social and human sciences, and agricultural engineering which will address the needs of the rural population;
12. We recommend introducing Occupational Health and Safety concerns in training and educational programmes in all of the above-mentioned disciplines at any level, from health care providers to rural workers and population, in order to build the necessary human resources and to provide services of great quality to the rural population and agricultural workers. Specific country needs and participatory approach should be addressed;
13. We urge the agricultural sector to realize its responsibility for healthy working and housing conditions by expanding suitable measures for workers and farms and by providing financial means for scientific and educational developments to support such measures;
14. We are committed to share our practice and experience in devising, implementing and evaluating educational programs for the improvement of the health of the rural population;
15. We are committed, as citizens, to advocate peace and justice, and the pursuit of the common good as the founding of scientific and professional achievement in our own field of expertise;

We hereby authorize the Congress Presidents, the EURIPA, IARM, ICOH and WONCA Working Party on Rural Practice representatives to sign this declaration on our behalf.

Submitted to the Assembly by Stefan Mandic-Rajcevic (Italy and Serbia)

Signed in Lodi, September 11th 2015

Claudio Colosio, ICRH President

Giampaolo Schillaci, Ragusa SHWA President

Tanja Pekez Pavlisko, President, EURIPA; Vice Chair WONCA Working Party on Rural Practice,

Hans Joaquin Hannich, President, IARM and Shuzo Shintani, Secretary General, IARM

Jukka Takala, President, ICOH and Gert van der Laan, Chair, the ICOH Scientific Committee on Rural Health , ICOH



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INTRODUCTION

Agriculture produces food and feeds through land use. This means that agricultural activities may produce wellbeing and richness but, if conducted in unsound ways, may bring about environmental depletion and pollution, health and safety risks for rural workers and harm to the general population through the commercialization of unsafe and unhealthy foods

In this frame, a keyword for the sector is “Healthy workers, producing healthy foods, without endangering the living environment”. Reaching the objectives claimed in this keyword means conducting a holistic approach, able to involve all the actors which may play a role in this process, each of them is supposed to contribute with his/her brick at the creation of the building of prevention.

Among the objectives indicated to reach the goal, there are:

- Promoting universal coverage and access of disadvantaged populations to Primary Health Care and Occupational Health Care, to improve the health status of rural workers and dwellers and to reduce social inequalities;
- Improving the overall quality of rural enterprises, to produce adequate amounts of high quality food, taking into account nutritional, safety and hygienic issues;
- Reducing the environmental impact of agricultural activities all over in the world, through the diffusion of “green economy” principles;
- Reducing the burden of disease attributable to occupational and environmental risks at the workplace, environmental pollutants generated by agricultural activities, and an unhealthy diet.

This will see the participation of the main national and international associations and organizations involved in Rural Health: the International Association of Rural Medicine and Health (IARM), which has decided to organize during (ICRH) its own 18th World Congress, the Wonca party on Rural Practice, which will organize specific sessions and lectures, the International Commission on Occupational Health (ICOH), and the European Rural and Isolated Practitioners Association (EURIPA)

Since 2008, every two years Ragusa hosts the Congress “Safety, Health and Welfare in Agriculture” (SHWA). The congress is mainly target at agricultural engineering, ergonomists and technical staff, interested in the diverse themes of prevention. For a lucky chance, this year SHWA was planned in Ragusa, only one week before the Lodi Event. Having in mind the main needs of agriculture and rural health, after a very short exchange of opinions we decided to join the events and to organize them together in Lodi.

The main reason of this decision is to “contaminate” each other Medicine, Agricultural Engineering, Ergonomics and other topics and to improve the opportunities to cooperate in the future. We are sure that with this decision we have open a long lasting track to be run in next years, with occupational physicians, OHS experts, GPs, Agriculture Engineering and Ergonomists.

Hope you appreciate the efforts, and welcome in Lodi!

Claudio Colosio

Eugenio Ariano

Giampaolo Schillaci



Section I

Rural Health - Book of Abstracts

Editors: Zanini L. and Colosio A.



Organized by International Centre for Rural Health of the University Hospital San Paolo of Milan, Department of Health Sciences of the University of Milan, Azienda Sanitaria Locale of Lodi and Department of Surgical Specialties, Radiological Sciences and Public Health of the University of Brescia.



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Welcome address

About half of the human population lives and works in rural areas, mainly engaged in agricultural activities. This ancient human activity produces food and uses land in a world where the demand for food is growing very quickly, and the quality and quantity of food are basic needs to ensure the health of millions of people. At the same time, agricultural activities are capable of causing environmental resource depletion and varying levels of pollution. Likewise, rural areas are directly linked with the wellbeing of entire communities, as demonstrated by the recent outbreaks of infectious diseases that were triggered in rural settings. Despite their major social, cultural, ecological and demographic relevance, rural areas are largely neglected by scientific research, health prevention and social protection. Rural inhabitants are suffering from an evident gap in life quality, sanitation, income, and distribution of social protection and economic benefits, including occupational health protection and services, as compared to urban dwellers. Importantly, rural communities are organized in villages, where agriculture and related activities are carried out very often by entire families, in which women, children and elderly represent an important proportion.

The village is the target of all preventive interventions in rural areas. Only a healthy village, inhabited by healthy dwellers, can produce healthy food for the entire community while respecting the living environment. At the end of the 16th International Congress on Rural Health, held in Lodi (Italy) on June 2006, the “Lodi Declaration on Healthy Villages” was approved, and the Campaign on Healthy Villages was launched. The Lodi Declaration highlighted that, due to the complexity and specificity of rural areas, the approach to rural health needs to be holistic, crosscutting, and integrative. Cross cutting needs include different levels of expertise (involving, for example, academia, rural health practitioners, rural community leaders and others), integration among disciplines (involving general medical practitioners, occupational and environmental medicine, agronomic sciences, veterinary medicine, rural sociology, and health systems), and collaboration among countries, particularly addressing the rural differences between the industrialized world, the growing developing countries and those countries still in transition. Consensus on these needs was partially achieved by the Cartagena Declaration issued during the 17th International Congress in Agricultural Medicine and Rural Health in October 2009, by means of which Latin America committed to strengthen Rural Health and Medicine in its region. The Lodi Declaration was adopted by the 18th International IARM Congress, and the Goa Declaration of December 12th, 2009 reaffirmed the relation between health, human rights, and economic growth underlining that health is more than a medical issue and that women’s and children’s health is a human rights issue and closely interlinked with the empowerment of women and girls resulting in gender equality.

However, the following specific objectives remain to be achieved:

- Promoting universal coverage and access of disadvantaged populations to Primary Health Care and Occupational Health Care, to improve the health status of rural workers and dwellers and to reduce social inequalities;
- Improving the overall quality of rural enterprises, to produce adequate amounts of high quality food, taking into account nutritional, safety and hygienic issues;
- Reducing the environmental impact of agricultural activities all over in the world, through the diffusion of “green economy” principles;
- Reducing the burden of disease attributable to occupational and environmental risks at the workplace, environmental pollutants generated by agricultural activities, and an unhealthy diet.

The opportunity:

Milan is hosting the Universal Exhibition in 2015. The central topic is “Energy for Life, Feeding the Planet”, by means of which the centrality of agriculture and rural areas in the world is strongly highlighted. This event constitutes a unique opportunity for organizing a four day event and calling professionals, experts and stakeholders from different areas of health and rural sciences unite jointly to address the varied

aspects of agriculture and rural health, aimed at priority setting, making rural health problems visible, and finding feasible and sustainable solutions for rural populations.

The proposal

This event is targeting all international experts in rural health in the world. It will be organized in such a way to ensure the participation of the main national and international associations and organizations involved in Rural Health along the lines already defined by WHO including its efforts towards the “Health for All” programme, by reinforcing Primary Health Care services as the way to achieve universal health service coverage, and, as highlighted in the Den Haag Conference, towards the need of an integration of Occupational Health services within Primary Health Care.

The main international associations active in the field will be also present: the International Association of Rural Medicine and Health (IARM), which has decided to organize during this Congress its own 18th World Congress, the Wonca party on Rural Practice, which will organize specific sessions and lectures, the International Commission on Occupational Health (ICOH), which will be present with five Scientific Committees, those on Rural Health, Occupational Toxicology, Toxicology of Metals, Occupational Health and Development, and Indoor Air quality and health together with the European Rural and Isolated Practitioners Association (EURIPA).

This means that in this event all the main actors active in the world in the field of rural health will be present: this is a promise for a future of prevention and health in Rural Areas.

Prof. Claudio Colosio
Congress President

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Keynote Lectures- September 9th 2015

Ethics in occupational and rural health

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Over the last two decades there has been increasing attention to questions of professional ethics in the field of occupational health in both developed and developing countries partly due to the changing world of work, demographic changes, introduction of new technologies. These changes led to the questioning of traditional ethical principles (principle of autonomy, beneficence, non maleficence and justice) and the emerging of ethical issues related to occupational health. Particularly outstanding is the role of the occupational health professionals (OHPs) whose choices embrace a larger number of ethical responsibilities if compared to healthcare workers as they are required not only to protect workers' health but also to meet the needs of all subjects involved in the decision-making process (employers, OHS professionals themselves, insurance system). This is particularly true, as an example, in the agricultural sector where the extreme fragmentation of small and family-run agricultural holdings, combined with the large presence of migrant workers, give rise to critical issues affecting occupational ethics. The need to balance risks and benefits of individuals and the interests of the wider community is not unique to occupational health. At this end, the International Code of Ethics for Occupational Health Professionals of the International Commission on Occupational Health (ICOH) represents a tool aimed at translating, in terms of professional conduct, the values and ethical principles in occupational health taking into account the highest professional standards and ethical principles. The principles included in the ICOH Code of Ethics have been worldwide successfully implemented in some national legislation (e.g. Argentina and Italy).

Agricultural Health and Medicine Education—engaging rural practitioners to make a difference to farmers’ lives.

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OBJECTIVES:

The Discipline of Rural Health—the interdisciplinary study of health and health care delivery in rural environments— is a well-recognised discipline globally. Within these rural populations, farmers and agricultural workers live and work. Despite increasing evidence indicating serious and ongoing inequities in health, wellbeing and safety, farming populations have lagged behind the health progress of metropolitan populations and other industries. Despite continued higher rates of workplace injuries, earlier morbidity, traumatic death and suicides in farming populations globally, there are few formal programs focused on Agricultural Health and Medicine (AH&M). Recognising this gap, a specialty postgraduate unit that focuses on the anticipation, diagnosis, treatment and prevention of illnesses and occupational injuries in agricultural populations was developed in 2010 in Australia through Deakin University [1]. The original curriculum was adapted from the University of Iowa (UoI) course[2] and was designed to enable health care providers to deal more efficaciously with particular illnesses and conditions, which farmers and agricultural workers, as distinct from other rural people, present. Additionally the curriculum aims to support agricultural professionals to play a role in preventing occupational illness and injury through increased health literacy.

METHODS:

It is five years since the course was introduced into Australia. Quantitative data were collected from students who had completed the AH&M unit to determine

- changes in students attitudes
- self-reported behavioral changes as a result of completing the course
- if students found the course to be professionally valuable
- the level of knowledge retention since taking the course in terms of major course concepts/objectives

Data was also collected from students in the USA who had completed the UoI program in the same period[3]. Data was analysed using descriptive statistics, frequencies and the chi-square test to consider similarities and differences

RESULTS:

Over 90% of the Australian students agreed the course improved their ability to diagnose, prevent and treat farming populations. Over 80% of past students were working in rural communities[4]. The AH&M course addressed in a disciplined method the health of a population with documented need and is in line with growing societal expectations that health professionals are knowledgeable about specific population-based issues.

CONCLUSIONS:

To address ongoing health disparities globally action is required to ensure health care providers are culturally competent to work in agricultural communities, health literacy is increased in the agricultural professions and global translation and implementation of AH&M a high priority.

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Indoor air pollution in rural areas: a priority for public health

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Introduction

Indoor air pollution in rural locations has been recognized by the World Health Organisation as an important and widespread problem (WHO, 2000).

In rural locations, combustion of biomass fuels is the major source of indoor pollution (WHO, 2006). Biomass fuel is any material derived from plants or animals, which is deliberately burnt by humans. Most of this cooking is done indoors with unvented stoves; combustion is very incomplete in most of these stoves, resulting in substantial emissions, which, in addition to poor ventilation, produce very high levels of indoor pollutants. The most important pollutants are particles, carbon monoxide, nitrous oxides, sulphur oxides, formaldehyde, and polycyclic organic matter, including carcinogens such as benzo[a]pyrene. Measured levels of air pollution in these houses greatly exceed indoor and outdoor air concentration; for example, indoor concentrations of particles are typically in the range 300–3000 mg/m³ and may reach 30000 mg/m³ or more during cooking periods.

Other sources of indoor air pollution in rural countries include environmental tobacco smoke, pesticides, smoke from nearby houses, burning of forests, agricultural land and household waste and use of kerosene lamps.

Health effects

Several studies have reported an association between exposure to biomass smoke and acute and chronic pulmonary diseases. By far the largest contribution to the disability adjusted life years lost arises from acute respiratory infections because of their high incidence and the mortality among young children. Asthma, interstitial lung disease, tuberculosis, lung cancer, low birth weight, perinatal mortality and effects on cardiovascular disease has been suggested.

Conclusions

Studies on indoor air pollution in rural areas, together with policy and macroeconomic studies, are required to develop preventive interventions. The goal of interventions should be to reduce exposure to indoor air pollution, jointly domestic energy and cultural needs and improving safety, fuel efficiency and environmental protection.

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Models and approaches for improving the access of rural workers to occupational health care

Agricultural Health program in Iran's Primary Health Care (PHC) system

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OBJECTIVES: KAP measurement and Improvement of Iranian Agricultural health program indicators.

METHODS: This is a cross sectional. The standard questioner was developed for data collection and samples were selected randomly from all Medical Sciences Universities.

A total number of 10000 farmers health surveillance files were investigated and analyzed by SPSS version 18.0 Software.

RESULTS: 37.5%, 50% and 53.5% of farmers had good performance in protection of hearing, eyes and skins respectively and 46% in use of personal protective devises, 88.9%and 36.6% of farmers had adequate knowledge about harmful effects of pesticides and work posture respectively and 64.5% in healthy behavior during work. There were 36% and 26% of farmers with heat and cold stress exposure knowledge respectively, 42% and 43% of farmers knew about work palace harmful agents and safety guidelines in agricultural respectively. And Agricultural Health Committee to be held percentage (in province and restrict) 35 and 60 respectively. Findings showed that a combination between occupational health services and Technical training to farmers, educating them and establishment of standards for Agricultural jobs and instruments are key concepts for farmers, products and environment health IMS system. Supervision of pesticides marketing is related with farmer's knowledge.

CONCLUSIONS: Our findings will suggest the combination of farmers training and health monitoring supervised by Agricultural Health Committee as a successful model for agricultural health program. Following these findings, Occupational Health in Farm Farmers School (IPM-FFS-OHM) will be our suggested approach.

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Efficiency and quality of rural health services in region of Kazakhstan

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OBJECTIVES: The objective of this work was to evaluate efficiency and quality of activity of rural outpatient clinics in Karasai district of Kazakhstan.

METHODS: To evaluate quality of health services, 500 rural respondents were questioned; focus groups of mothers, elderly women and young people were carried out. Evaluation of efficiency of work of rural outpatient clinics 19 performance indicators were calculated based on reporting documents, including, for example, the rate of prevented maternal death at PHC level, the share of successfully treated women with extragenital pathology among childbearing age women, etc.

RESULTS: Analysis of factors associated with access to health care showed that the probability of visiting a doctor is affected above all by a person's gender, education, health and self-esteem, in the last instance, by financial situation.

A summary of indicators of the quality of medical services provided by the ROC for 2012 showed their high efficiency and good quality of their activities: coverage of pre-natal screening and contraception women with absolute contraindications to carrying a pregnancy above 94%; full enrollment of patients with diabetes and free medicine provision. Reduced child mortality. Coverage of planned population by fluorographic examination was below 70%.

39% of the respondents received medical services in 2012. The quality of medical services received in the previous 12 months prior to the study evaluated by respondents as satisfactory. Less than half of respondents (46%) rated the quality of care received more as good, 16% - very good, 7% of respondents rated the quality of service excellent; 13%- rather bad, 8% - poor quality of medical services, and 4% - as very bad.

CONCLUSIONS: Assessment of 19 indicators of performance of rural outpatient clinic in Karasai district of Kazakhstan showed its good efficiency. The surveyed rural population of villages evaluated received health services as satisfactory.

Occupational medicine and rural health in R. Macedonia - current perspective and future directions

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Background. Working population in R. Macedonia encompasses over 950.000 people and there are over 110.000 agricultural workers. Considering the fact that about 40% of the population in Macedonia is rural, Ministry of Health ensured good health coverage of rural population with primary health care services. Despite that, agricultural workers are not adequately covered by specific health care regulated by the occupational safety and health legislation. Key informant survey identified agriculture as high risk sector in the country leading to Program for health and work ability assessment in agricultural workers in R. Macedonia, initiated by the Institute of Occupational Health of RM and supported by the Ministry of Health.

Methods. Retrospective analysis of the data obtained by the Program conducted from 2009 to 2013 in different parts of the country. Over 6.500 agricultural workers completed specially designed questionnaires (demographics, health behaviors, occupational history, preventive measures, health status, and work-related health problems). Health promotion activities (including distribution of thematic brochure) were implemented in all study subjects. Preventive medical examinations (occupational medicine specialist and psychologist check-up, lung function tests, ECG, standard analyses of blood and urine) were conducted in about 2.000 randomly selected subjects having agriculture as a primary occupation.

Results. Study identified the most frequent agricultural activities (cultivating vegetables, planting, digging in the fields), occupational hazards (inadequate climatic factors, dust, chemical agents), work organization aspects (12 hours workplace activities during season) as well as the most important work-related symptoms (back pain, pain in the extremities, and fatigue). None of the participants was previously examined by occupational medicine specialist. Clinical check-up highlighted cardiovascular, musculoskeletal, and respiratory diseases.

Conclusion. The results of the Program were disseminated nationally and internationally. It set scientific methodology contributing to the identification of both specific occupational hazards and work related health problems. Specific measures aimed to improvement of health and work ability in agricultural workers and rural population were defined.

The use of occupational health care services and farmers' opinions concerning them in Finland

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OBJECTIVES: There are approximately 68 000 insured farmers in Finland. For farmers and self-employed persons it is voluntary to arrange occupational health services for themselves. Farmers' occupational health services (FOHS) are mostly arranged in municipal health care centres. In the FOHS protocol, an occupational health nurse and the local agricultural advisor, occasionally accompanied by an occupational health physician and/or a physiotherapist, visit the farm to survey work conditions (farm walk-through). The health check is done with the occupational health nurse and it is extended by occupational health physician if there is any suspicion of work-related diseases, mental disorders or chronic illness affecting work ability, for example. A decree, effective from 2014 on, demands more co-operation between farmers and health care professionals in the FOHS. The main objective of this quantitative study was to investigate farmers' satisfaction and contacts with FOHS in 2014 compared to 2004.

METHODS: The data was collected in 2014 via a computer-aided telephone interview system resulting in responses from 3117 farmers. Most of the data was collected from full time farmers (n=2122). The results are compared to a similar study conducted in 2004 (n=1182).

RESULTS: Of farmers interviewed, 64% had purchased FOHS for themselves in 2014, whereas the figure in 2004 was 54%. In 2014, 87% and in 2004, 81% of farmers were satisfied with the services. A Farm walk-through had been done during the last four years for 78% of the farmers, and 91 % of them were also satisfied with it. A health check had been conducted for 82% of the farmers in 2014, when in 2004 the figure was 69%.

CONCLUSIONS: In Finland, FOHS have improved. There are more activities and farmers reported higher satisfaction with the services they receive. The challenge is to make FOHS a more interactive process.

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Migrant agricultural workers and Canada's "not so universal" health care system: lessons learned from an effort to improve access to health care in the province of Ontario

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BACKGROUND:

There are approximately 40,000 migrant agricultural workers (MAWs) employed on temporary labour contracts in Canada, primarily from Mexico and the Caribbean. Although they have legal access to provincial health care under Canada's "universal system," these workers experience numerous practical barriers, including: long work hours; limited clinic hours; lack of transportation; delays in receiving health cards; lack of information about and integration into the local health care system; dependence on employers, and resulting confidentiality concerns; and language and literacy barriers. For the first time in 2014 a pilot program was initiated that was designed to mitigate barriers through provision of walk-in style primary care clinics and community outreach in two regions of Ontario with the highest concentration of MAWs. This presentation assesses this program, outlining challenges and successes, and offers strategies for other service provider organizations and community partners interested in improving care for MAW populations.

METHODS:

Data were gathered in two regions via clinic records, a convenience sample of client surveys (N=86), 3 focus groups with selected key system stakeholders, clinicians, community partners, and other clinic participants (N=24), physician surveys (N=7), and qualitative interviews (N=2).

RESULTS:

There were 462 workers seen at the clinics (visits = 715). Client survey respondents (N=86) stated their health needs were met and the location of the clinic was easy to find. The predominant health issues presented, impact of outreach on community capacity, lessons learned, and continuing challenges will be discussed.

CONCLUSIONS:

Although these programs exceeded projected targets, only 5% of the MAW population in the two regions was served. Providing follow-up and secondary care remained challenging. This clinical model is a demonstration of an enhanced/specialized public system model bolstered by support from community partners. Future programming will continue to build on this model.

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Slavery and other forms of human exploitation

The exploitation of migrant workers in the Italian agricultural sector: a case study from a Ghanaian community of day-labourers in northern Apulia

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The notion of slavery traditionally entails extreme exploitation, property rights and individual ownership. These concepts have been reflected in various legal instruments as well as in the popular understanding of slavery for centuries. Although the existence of legal definitions, the question of identifying what sort of practices can be classified as forms of slavery has never been an easy task, ranging between literally and rhetoric interpretations.

Even in the contemporary debate, the attempts to define and analyze slavery still rise a lot of questions: what counts as a slave in the contemporary world? When forms of contemporary extreme exploitation fall under the category of slavery? These questions open up a debate that seems to fit particularly well in the analysis of the working and living conditions of west-African migrant day-labourers in the southern Italian agricultural sector. In the last decade, the recruitment system headed by caporali (i.e. go-between the landowner and the daily workers that exercise physical and psychological violence on the latter), and the exploitative working conditions of these migrants have sparked the debate whether they can be defined as "new slaves".

Through an ethnographic analysis of life histories and work biographies collected during my field research in Apulia, a region renowned as the biggest Italian tomato district, within a group of Ghanaian seasonal workers, I'll try to reconstruct the paths of the "things" - the tomatoes - and that of these workers, and to answer the question: are they slaves?, showing how necessary is to place the living and working experiences of these migrants at the core of the contemporary anthropological debate on human bondage and slavery.

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Emancipation through integration. Access to drinking water and food in the Guéra region, in rural central Chad

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Between the 16th and the 20th century, the Guéra region has been a slave-reservoir for the neighbouring Muslim sultanate of Wadai. Local people used to hide in the mountains in order to flee Wadai razziah. Therefore, when the French conquered and appeased the region in the 1920s, they found a very scattered ethnic and social landscape. In 1923 the French colonial government administratively organized the territory, appointing a customary chief for every local ethnic group. The colonial and postcolonial states were building upon these customary authorities, which still play a crucial political role. The people locally stigmatized as slave- descendants, called Yalnas, got a customary chief and were integrated in the state machine, while the other stigmatized group, the blacksmith, called Haddad in local language, could not have their customary authorities and remain at the margin of the state. This paper shows how the integration in the state machine through customary authorities is a clue condition, nowadays, to control resources as water wells and cereal banks. In a context where the main health issues are malnutrition and diseases related to polluted water consumption, the ethnic belonging harshly affects health conditions. Through examples of different water wells and cereal banks in villages around Guéra, the paper will present the different dynamics behind the access to these resources, showing how Yalnas were quite effective in getting access to them despite their stigma, while Haddad have a much more difficult access to both drinking water and staple food. This case shows the complexity of health policies in rural contexts and its strong link with local politics dynamics.

Enduring marginalities: Social hierarchies and agricultural labor in Southern Morocco

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The Black population of Morocco (Haratin) have historically occupied marginalized position in the social, economic and political life of the country. Even though they were considered legally free, the Haratin were ranked between free populations (aḥrar) and the slaves and their descendants (ʿabid) in the social hierarchy, dominated by the descendants of the Prophet (shorfa). They worked as specialized craftsmen and shared croppers for their Arab and Berber patrons, keeping on 1/5 of the harvest. Dominant Arab and Berbers groups define them as “people without origin (aṣl)” —the cultural concept of aṣl indicates both geographical and genealogical origin.

This paper explores the changing system of social relations and agricultural labour in Southern Morocco in the light of the emergence of salaried work, school education and transnational mobility in postcolonial Morocco. Thanks to the opportunities of social mobility and emancipation opened during the French Protectorate (1912-1956) the Haratin could find alternatives to exploitative agricultural work in the rapidly booming coastal cities and in migration to French colonies in Algeria, and then to Europe. Salaried work and migration enabled them to escape labour exploitation and at times to accumulate the financial means to buy land and build a sense of belonging, from which they had been excluded. In postcolonial Morocco, policies of national development, mass education and the abolition of privileges based on origin catalyzed these processes. Tracing these historical developments, this paper explores the continuity and discontinuity in the form of marginalization and exclusion that the Black population experience today.

The Jijiyaabe and the Rimbe of Southern Senegal. The rural predicament of the legacies of slavery

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OBJECTIVES: To discuss how a past of violence and exploitation shapes the social world and livelihood of Southern Senegalese peasants.

METHODS: Oral history and ethnography

RESULTS: Scholars, state officials, development experts, and the population itself describe the eastern Casamance as an enclave. Dakar, the capital city of Senegal is far. The roads are poor, the transports bad and expensive. Besides smuggling, the two most flourishing economic activities of this part of Senegal - the irrigated rice project of the Ananbé basin and the weekly market of Diaobé – are under the control of external investors and entrepreneurs. It is against this background that I study the legacies of slavery. Until the beginning of the 20th century, the eastern Casamance served as a ‘slaving zone’, i.e. an area ravaged by raids that fed the internal and external slave trade. The traces of this not-so remote past loom large in the memories and daily lives of the population. Jiyaado (plur. jiyaabe) is the local term that translates the idea of ‘slave descendant’. Dimo (plur. rimbe) identifies the offspring of nobles and slave-owners. There is tension between the two social categories as much as collaboration that help counter the hazards of rural life (droughts, lack of health and educational facilities, the increasing prizes of seeds and fertilizers, cattle epidemics).

CONCLUSIONS: This case study contributes to debates on the legacies of slavery by identifying two levels of analysis: the macro level of national and international political economy and the micro one of people’s life trajectories.

(Research for this article has been supported by the European Research Council under the European Union's Seventh Framework Programme (FP7/2007-2013)/ERC Grant agreement n° 313737: Shadows of Slavery in West Africa and Beyond: A Historical Anthropology, and has received authorization by Bicocca Ethic Committee).

The social life of the global greenhouses. Stigma, servile work and labourers' vulnerability in Jordanian agribusiness

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Greenhouse production are today the globalized icon of agribusiness and intensive agriculture for the market and are presented widely as symbols of modernized and successful rural landscape. In the Jordan Valley, as in other regions, they represent icons of modernity and productivity. Indeed, intensity is what characterized these work places: intensity of climate conditions, intensity of profits of agricultural managers, intensity of unprotected workload, of exposure to the intensive use of chemicals and fertilizers (often banned in other countries). In short they well represent, the modern servile work of wage labourers, who often are displaced, migrants or are composed of a strong feminization of labourers.

In Jordanian Jordan Valley, working 'juwwa al biut al-plastic' ("the house of plastic"), inside the greenhouses, generally involves exhausting and dependent work relationship, and from local perceptions, it is itself a stigma of low status: the shame of working in servile conditions, of promiscuous labourers, of devalorized farm work of Egyptian migrants, Pakistani displaced, Palestinian refugees or local women of low-status are the hands "at disposal" behind winter tomatoes exported to the Gulf or north-European markets.

In this frame the local feeling of being vulnerable and ill is often linked to this new environments and work conditions, where the social and cultural reality vulnerability cannot be detached from the medical one: illness due to chemical exposure as much as the dishonour of servile work, the dependence to highly flexible work-hours for women, as much as the blackmail of visa for work, or hiding for work (in case of illegal migrant labours) for migrants, the stigma of rural work value, living in huts in farms built with recycled pesticides plastics and boxes, all aspects that compose the social life of agribusiness modernity.

Public Health Strategies and governance in rural areas

The use of QFD for safety assessment of machinery

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In last decades Quality Function Deployment (QFD) method has been used widely in most of industry sectors, focusing the attention on the so-called Voice of Customers for the development of higher quality products and services. Only recently its use has been extended to the improvement of different properties of products and services, such as: environmental sustainability, reliability, maintainability, etc.

Instead, it has to be underlined that a few research works on the use of QFD in the field of products' safety have been presented so far.

This is due to the fact that main issues and targets concerning products' safety are defined by laws and regulations (e.g. directive 2006/42/EC): whenever a higher level of safety can be achieved it becomes the standard level.

Nevertheless, QFD can be support designers in optimizing safety characteristics together with other characteristics of the product, allowing us to guarantee an adequate safety level of the product without reducing other performances.

In this study, a specific Safety-QFD framework has been implemented through its application to gardening machinery. More in details, the House of Quality was used to evaluate the relationships between causes and effects of possible risks of the product user.

Results achieved show that such a procedure can be used for the risk assessment of products effectively, allowing the designers to obtain the priority of interventions aimed at increasing the safety level of the product. In particular it represents an ease-of-use tool in case of re-design or update of machines due to safety requisites evolution.

International and regional approaches to safety and health requirements for designing agricultural and forestry machinery

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The presentation gives a short overview of the rules that apply on agricultural machinery related to the health & safety aspects in the main regulated regions of the world. It is not a surprise to discover that the various regulations are dispersed and fragmented, both in the pro-active stage (during design and manufacturing stage) and the re-active stage (during the use of and accidents with machinery).

The product safety standards are not globally, the conformity assessment procedures are different and must often be repeated per region. Market Surveillance is sometimes not well established or left to individual or collective lawsuits. The EU28 H&S Directives (MD, EMC, ...) had a leading role and were often copied, however without mutual recognition. All this has resulted in a very complicated scheme of approval marks, 3rd party certifications and declarations.

Of course the industry prefers unique and global standards and conformity assessment procedures, together with mutual recognition.

Further in the presentation, some peculiarities of the EU Machinery Directive are highlighted from the viewpoint of the manufacturers (and end-users), in particular about risk assessment methods and the various kinds of reasonably foreseeable misuse.

To illustrate the latter theme, there is the writer's viewpoint about an example of deficient translation of the Essential Health & Safety Requirements of the Machinery Directive into a CEN product safety standard.

Market surveillance activity as a way to ensure health and safety of machinery, eliminate unfair competition and help manufacturers in designing

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Market surveillance can be carried out at any stage after the construction of the machinery is complete, as soon as the product concerned has been made available for distribution or use in the EU. For these reasons it is important that this activity is developed also at earliest stage, when the machinery is not already in use by the operators. The machinery surveillance joint project Italy – France at the begin of 2000, involving different kinds of machineries also in the agricultural sector, revealed that developing market surveillance activity during fairs increases the number and typologies of machineries which can be analyzed at the same time. Starting from that experience INAIL developed a specific activity within the national project regarding the promotion of health and safety in the agricultural, forestry and zootechnical sectors (progetto CCM “Promozione della salute e Sicurezza nelle attività agricole, zootecniche e forestali”) approved by Ministry of Work. In particular, in Italy during the main agricultural machineries international fairs a market surveillance campaign has been organized.

Some specific typologies of agricultural machineries have been preliminary chosen on the basis of accident data or significant possible non conformity due to recent changes in the reference harmonized standard. This led to about 150 machineries investigated in more or less three years, remarking that market surveillance is an essential instrument in as much as it ensures the proper and uniform application of Directive, not only ensuring health and safety of machinery but also providing help to manufacturers in designing compliant machineries and eliminating unfair competition.

A new way to register and prevent accidents involving agricultural and forestry machinery

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In the agricultural sector, much more than in other working sectors, there are several operators (employees or not) for which an eventual accident is not registered by the traditional detection systems used for collect and elaborate data referring to accidents at work. In particular, in the agricultural and forestry sector this kind of operators are mainly self-employed workers for whom the agricultural activity is not predominant and hobbyists. These subjects are not covered by institutional working insurance. Thus, accident which may involve these typology of workers is not accounted among the official statistics of the National Institute for Insurance against Accidents at Work (INAIL). For this reason the INAIL research unit involved in the agricultural sector in between 2007 - 2009 developed a specific observatory in order to collect all the information about accidents involving agricultural machineries which occurred also to self-employed people and hobbyists. This activity interests also the local inspectors for safety at work and it has been developed within the national project regarding the promotion of health and safety in the agricultural, forestry and zootechnical sectors (progetto CCM "Promozione della salute e Sicurezza nelle attività agricole, zootecniche e forestali") approved by Ministry of Work. Nowadays it is possible to collect all the information in short time and in the same manner all over the national territory and consequently use and analyze these data for different purposes (e.g. elaborate statistics, use the information acquired for verifying the relationship between the accident and the possible lack of machinery safety requirements, etc.).

Diagnosis and prevention of musculoskeletal disorders in agriculture

Comparison of the Strain Index and OCRA Checklist for Risk Analysis of MSD

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Introduction

The purpose of this study was to characterize the inter-method reliability of two physical exposure assessment methods, the Strain Index (SI) and Occupational Repetitive Actions (OCRA) Checklist, often used in occupational health studies to assess the risk of musculoskeletal disorders.

Methods

Eight raters used the SI and OCRA Checklist to assess task-level physical exposures to the upper extremity of workers performing 21 cheese processing tasks. Inter-method reliability was characterized using proportion of overall agreement, Bowker's test of symmetry, Cohen's weighted kappa, and Spearman correlations.

Results

Strain Index and OCRA Checklist assessments classified job tasks into similar risk categories. Inter-method reliability was moderate overall but poor for more complex tasks.

Conclusion

The SI and OCRA Checklist are similar physical exposure assessment methods and either may be appropriate when assessing repetitive job physical exposures to the upper limbs.

Differences in musculoskeletal occupational disease incidence and notifications between the Po Valley and the Appennines

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INTRODUCTION

In 2010 occupational diseases (ODs) notifications in agriculture in Italy were 6380. Particularly musculoskeletal disorders notifications were 76% of all notifications. The aim of this study is to evaluate differences in musculoskeletal ODs notifications between farmers working in mountain and in plain, because of they have different musculoskeletal occupational hazards.

METHODS

We analyzed reports of musculoskeletal ODs notified to obtain a compensation between 1997 and 2013. We chose to study the province of Bologna because of its clear differentiation between plain (the Po valley) and mountain (the Appennines) areas. We estimated crude rates per 1000 per year using as a denominator the workforce in agricultural sector (census 2011). We tested the equality of proportions between plain and mountain rates, accepting an alfa-error of 0.05.

RESULTS

We found significant differences between plain versus mountain rates for
-lumbar herniated disc: 0.8(95%CI 0.62-1.01) versus 0.36(95%CI 0.23-0.55);
-knee arthritis and others knee diseases: 0.40(95%CI 0.28-0.56) versus 0.16(95%CI 0.08-0.30);
-shoulder diseases: 1.29(95%CI 1.07-1.56) versus 0.81(95%CI 0.60-1.07).

DISCUSSION AND CONCLUSIONS

Results lead to think musculoskeletal ODs incidence among farmers is higher in the Po valley than on the Appennines. This is unexpected, considering what we can presume on the basis of occupational hazards. If we could consider as expected such a tendency in agriculture for lumbar herniated disc, because of farmers working in extensive crops spend a lot of time using tractors and are more exposed to whole-body vibration, we cannot do this for knee arthritis: on mountain, farmers work in rough terrains, rising ground and are so more exposed to knee biomechanical overload. To explain those figures, it could be hypothesised that reporting of ODs is not just depending on occupational hazards or work-related diseases real incidence, but probably also on other issues like underreporting, overdiagnosis and cultural or socioeconomic factors.

Dairy Consortium International Perspectives on Health and Safety among Dairy Workers: Challenges, Solutions & the Future

Comparison of upper limb muscle activity between US and Italian industrialized Dairy operations

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Background:

Biomechanical risks bring about a significant burden of musculoskeletal disorders across all industries (OSHA, 2014), and dairy milkers of the modern milking industry are exposed to these risk factors. Several variables may affect the physical load of the workers and the related musculoskeletal risk. Among these, prominent are herd size and level of task specialization (Doupbrate, Gimeno, et al., 2013). Dairy systems are similar in North America and Italy, as using loose-housing dairy parlors is common, but the size and the levels of specialization are different. Therefore, a comparison between European and USA milking systems might be very useful to collect a better understanding of the main musculoskeletal risk determinants. Aim of this study has been the comparison between loose-housing parlor systems in USA and in Italy, focusing on muscle activity and physical load, through systematic collection of surface electromyography data and selected information regarding working modalities. This study is part of a bigger study whose aim is investigate risk factors of musculoskeletal disorders in dairy workers and adverse clinical outcomes.

Methods:

The study has been conducted with the same protocol in USA and in Italy. In particular: 29 healthy dairy workers were recruited from three large-herd dairy farms in Colorado and 39 dairy workers were recruited from 21 small dairy farms in Lombardy region of Italy. All workers were asked to report the presence of musculoskeletal symptoms (MSS), and the anthropometric data were collected. As indicators of muscle activity we used: the Root Mean Square(RMS), the Amplitude Probability Distribution Function(APDF) and the percentage of Muscular Rest(MR) obtained by processing surface Electromyography data collected during working activities using Biometrics DataLOG (Biometrics, England).

Results and a conclusion: Dairy milking in Coloradan large herd operations demonstrated higher mean of Root Mean Square, 50th percentile APDF, and %MR than Italian small herd operations. The differences in RMS mean and 50th percentile APDF suggest that large herd dairy workers may suffer a musculoskeletal risk due to extended high average muscle activity (Jonsson, 1982). However, the lower % MR observed in the Italian workers suggests that they too are exposed to the risk of musculoskeletal disorders.

Dairy Worker Safety Training: Current Challenges and Opportunities for Enhanced Effectiveness

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BACKGROUND:

The U.S. dairy industry relies heavily on immigrant Latino labor. This underserved population is exposed to a variety of safety risks, some inherent to their work environment. Factors that contribute to safety and productivity of dairy workers, including the quality of safety training programs, are not well understood.

OBJECTIVES:

The objective of this study was to identify dairy worker perceptions regarding barriers to and opportunities for enhanced safety and productivity.

METHODS:

Seven focus groups were conducted with Spanish-speaking employees on dairies in Colorado and South Dakota. The workers were asked to describe previous and current job experiences, communication with management, perceived importance of safety, and policies, procedures and safety training currently in place. Audio recordings of focus groups were transcribed and translated into English for data analysis, which consisted of open-coding by two researchers to generate a list of themes. Themes identified were inserted into the Contributing Factors in Accident Causation Model to assess factors relevant to safety and worker productivity.

RESULTS:

Forty-six workers participated in the focus groups and identified aspects of their work environment and job demands that influence their safety and performance. Factors identified by participants included workload and pressure to work fast, animal handling hazards, numerous environmental exposures, machinery and chemical hazards, lack of attention by management, communication barriers, cultural differences, and content, delivery method and extent of training. Workers identified a need for greater recognition, fair treatment, timely addressing safety hazards, transparent communication and comprehensive and ongoing safety training.

CONCLUSIONS:

The findings of this study provide valuable insight into dairy worker perceptions of the organizational, environmental, individual and social factors of their work that affect safety and performance. These findings should help inform the development of training programs to improve the safety and productivity of dairy workers.

Ergonomic challenges in modern milking parlors

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OBJECTIVES: Milking cows is coupled with awkward postures, repetitive movements, a cold, hot or wet working environment and many more risk factors for developing musculoskeletal disorders. Several international studies showed that milkers working in separate milking parlors display high levels of pain and disorders in the musculoskeletal system. The prevalence among females is significantly higher. Ergonomic design intends to reduce operator fatigue and discomfort. One of the challenges to fit worker and equipment in dairy parlors is the additional component of the human animal interaction.

METHODS & RESULTS: Precise investigations of parlor design showed a range of approximately 1 m to suit the body height of the worker regarding depth of pit and udder-floor distances and anthropometrics altogether. Horizontal distances add up to the vertical differences and range between 30 and 80 cm also exceeding the arm length of the workers in many cases. The weight of milking clusters also differs. The large variation within one parlor does not allow optimal work place design for each human-animal interaction. 70% of the cows within the optimal height were the best to achieve.

CONCLUSIONS: Technical measures available to reduce the workload are adjustable floors, service arms, indexing or automatic cluster removal. None of these technical aids is able to fully compensate the described variation. Therefore a combination of ergonomic equipment is necessary to reduce the workload. For new parlors more attention needs to be paid on the dimensions to reduce the distance between worker and animal. The needs of female workers should also get more attention.

The Quiet Indian Revolution in Italy's Dairy Industry

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OBJECTIVES:

This paper discusses labour migration from the Punjab region of India to Italy's dairy industry. Based on anthropological fieldwork, it analyses how Indian immigrants have managed in a very short period of time to establish an economic niche for themselves as cow milkers on small dairy farms scattered throughout northern Italy. Indeed, it is estimated that Indian immigrants represent 90% of the workers in this sector.

METHODS:

Three main groups are interviewed (ethnographic methodology): employers, dairy workers, and the families of dairy workers (both spouses and children).

RESULTS:

This research reveals how Indians came to be favoured by Italian employers over other immigrant groups; how Indian dairy workers view their work and their future prospects; and the experiences of their family members, particularly of school-aged children who face stigma and prejudice from their classmates. It also discusses the strategies used by Indian immigrants to access this sector and explains how low-caste workers are disadvantaged by upper-caste social networks.

CONCLUSIONS:

It concludes by arguing that European migration policy also needs to make room for low-skilled labour in certain sectors of the economy. The belief that only highly skilled labour will lead to successful integration is contradicted by this research.

Occupational health and safety experiences in automatic milking

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OBJECTIVES:

Research indicates conventional pipeline and parlor milking exposes dairy farmers and workers to adverse health outcomes. In recent years, automatic milking systems (AMS), which typically reduce the labor requirement in milking, have gained much popularity in Finland and elsewhere. However, there is only limited information on the occupational health and safety issues in the AMS. We aimed to study the occupational health and safety experiences in AMS, compared to conventional milking.

METHODS:

An anonymous online survey was sent to all Finnish dairy farms with an AMS in 2014, one owner-operator from each farm. Previous work experience on conventional milking was an inclusion criterion for this study.

RESULTS:

Altogether 228 usable responses were received (25.2% response rate). The respondents had a total of 321 automatic milking boxes (range 1–5 per farm). The majority of the respondents found that AMS has brought flexibility to the organization of farm work, and it has increased leisure time, quality of life, productivity of dairy cattle work, and the attractiveness of dairy farming among the youth. In addition, it was found to significantly reduce the risk of occupational injuries and diseases as well as physical stress on the musculoskeletal system. However, training heifers to use automatic milking was emphasized as a high risk task that had resulted in several injuries. In addition, manual handling of reject milk and the daily cleaning of the AMS caused some physical stress to many farmers. In general, mental stress had either declined or remained the same after switching to AMS. However, some indicated increased mental stress because of the demanding management of the AMS. The majority perceived at least some mental stress due to occasional nightly alarms caused by the AMS and the lack of adequately skilled farm relief workers, hired labor, or both.

CONCLUSIONS:

Based on this survey, AMS has significant potential in the prevention of adverse health outcomes in milking of the dairy cows. However, certain characteristics of the AMS require further attention with regard to occupational health and safety.

Milking their Health

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OBJECTIVES:

The dairy industry is Victoria's, Australia's largest rural industry, with a gross value of raw milk production of around \$2.48 billion in 2010-11. The industry is mature, well resourced, well organised and internationally competitive.¹ However, there is a lack of data and understanding of specific health statistics of rural farming populations. In 2005, 210 participants (109 men and 101 women) commenced a three year program, held across 11 separate locations. A recommendation was that further analysis of the study population be undertaken. This funding was received in 2010.

METHODS: Ethics approval was granted by South West Ethics Committee. Health assessments were conducted at the beginning of the workshop and required participants to fast for ten hours. Total cholesterol and blood glucose were measured, blood pressure taken, using both standard sphygmomanometer (as used in the original programs) and electronic sphygmomanometer. Height, weight, waist and hip circumference were also measured and body mass index (BMI). A single beam Omron™ Bioelectrical the health assessment to link in with the respiratory session of the workshop.

Pre and post knowledge surveys were also done to assess retention of health information and literacy.

RESULTS: In 2010, 71.4% (150 participants— 73 men and 77 women) of the original participants returned. Statistically significant changes over the 60-month (5 years) timeframe include improvement in systolic and diastolic blood pressure and decrease in cholesterol. Improvements were noted in blood glucose and waist circumference for women —not significant —but defied the normal aging process and decreased rather than increased. The results including health literacy will be discussed.

CONCLUSIONS:

This longitudinal study increases our understanding of what impacts farming family health and identifies measures to improve their health, wellbeing and safety. Many of the specific strategies to improve farming family health were provided by the farmers themselves.

Health of the Rural Population and workers

The current status of knowledge about risk of hemolymphatic cancer among farmers

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OBJECTIVES:

I will review the results of recent large population-based case-control studies conducted in Europe and the USA and the US Agricultural Health study to highlight possible agents responsible for the excess of specific lymphoma subtypes among farmers.

METHODS:

The largest case-control study on lymphoma conducted in Europe and the US agricultural Health study included a detailed occupational history, particularly concerning agricultural jobs. Agronomists and expert farm owners and supervisors helped in identifying the specific agents used for each crop by time period and study area. The specific job module for agricultural occupations included information on previous epidemics among the livestock and the disinfectants used to treat the animals.

RESULTS:

Because of the current low prevalence of agricultural workers in population-based studies, even large individual studies cannot reach the statistical power required to test associations with specific agents. However, the results of the European study showed a significant dose-related increase in risk of chronic lymphocytic leukaemia associated with use of organophosphates, with glyphosate, widely used as a herbicide, as a strong contributor among this class of chemicals. No association was observed with use of the herbicide 2,4-dichlorophenoxy acetic acid (2,4D), while a possible role of 2-methyl-4-chlorophenoxyacetic (MCPA) was suggested, but could not be assessed. Organochlorine insecticides did not show an association. Contact with livestock showed a complex effect on risk of B-cell lymphoma subtypes, with protection against their development in adulthood when occupational and household contact started early in life.

The results of the US Agricultural Health study show that different specific chemicals, used for different purposes might be involved.

CONCLUSIONS:

While it seems that specific chemical agents might be implicated in the excess of hemolymphatic cancer among farmers, further large pooled analyses are warranted to identify them with greater precision.

Health of the Serbian rural population

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OBJECTIVES:

The right to health is one of the most important factors affecting the quality of life in rural areas. Residents of the villages, although exposed to greater health risks than the urban population, often have limited access to the health system. Due to the relatively poor transport infrastructure they have limited access to primary health care services and lot of difficulties in access to specialist services in secondary and tertiary health care institutions. It should be mentioned that rural population often needs more health care services than the population in the cities. Their increased needs are consequences of the heavy physical workload, usually longer than eight hours, work inappropriate climate conditions, exposure to pesticides, biological hazards and ultraviolet radiation. It should be noted that activities of rural population often includes dangerous tasks which leads to increased risk of occupational injuries and consequently increased use of health care services.

METHODS:

The health and burning problems of the Serbian rural population are explored and described using standardized questionnaires and public sources of data available.

RESULTS:

Life in the Serbian country side is characterized by a life in large households involving several generations and thus creates opportunities for intergenerational conflicts. Since in the countryside there are no clear boundaries between the living and working environment, family relations are knotted with relationships at work and may cause adverse health effects. A particular problem in rural areas is child labor, especially in some areas where there is a practice of including children in agricultural processes in which they are exposed to the same hazards and risks as well as adult members of the family.

CONCLUSIONS:

In order to solve some of the burning issues in providing adequate health care to Serbian rural population Serbian government should establish multi-sectorial managing board which will coordinate activities of different stakeholders.

The potential to detect and prevent health problems in the agriculture sector by using OHS data

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Background

In Belgium, agriculture is a small sector with average 2 employees per company. Remarkably, the proportion of non-family workers has increased from 4% in 1980 to 20% in 2013. Agricultural employees are medically followed-up yearly by Occupational Health & Safety (OHS) Providers because of exposure to pesticides, ergonomic hazards and noise.

Methods

We compared OHS medical data of 2700 agriculture workers with 260183 employees of other sectors to detect the main health issues for this sector. To illustrate the potential of OHS data to describe evolution of health problems, a multilevel analysis was performed with BMI data obtained between 1993 and 2014.

Results

Agriculture is a sector with mainly young male workers (68% versus 52% in other sectors). The consumption of medication was consequently lower (33,6% versus 47,9%) except for the following classes: respiratory (16,3% versus 15,0%), cardiovascular (33,6% versus 28,2%) and locomotor problems (19,0% versus 15,5%). Hearing loss was observed in 5,2% (versus 3,3%) workers and 11,2% (versus 9,1%) had an FEV1 < 80%. 21,6% suffered from hypertension (versus 17,7%). 55,2% did not practice sport (versus 38,5%), while 53,0% had a BMI >25 (versus 51,3%). BMI increased with age, but was largely dependent on gender and on BMI at start of employment. Increase in BMI was higher when BMI at start was high.

Conclusion

This study illustrates how OHS data can be used for the detection of agriculture-specific health issues, which are now being used for the implementation of a sector-oriented health surveillance program.

Heat stress, dehydration, and kidney function in sugarcane cutters in El Salvador – a cross-shift study of workers at risk of Mesoamerican nephropathy

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OBJECTIVES: An epidemic of progressive kidney failure afflicts sugarcane workers in Central America. Repeated high-intensity work in hot environments is a possible cause. The aim was to assess heat stress, dehydration, biomarkers of renal function and their possible associations. A secondary aim was to evaluate the prevalence of pre-shift renal damage and possible causal factors.

METHODS: Sugarcane cutters (N=189, aged 18-49 years, 168 of them male) from three regions in El Salvador were examined before and after shift. Cross-shift changes in markers of dehydration and renal function were examined and associations with temperature, work time, region, and fluid intake were assessed. Pre-shift glomerular filtration rate was estimated (eGFR) from serum creatinine.

RESULTS: The mean work-time was 4 (1.4–11) hours. Mean workday temperature was 34 to 36 °C before noon, and 39 to 42 °C at noon. The mean liquid intake during work was 0.8 L per hour. There were statistically significant changes across shift. The mean urine specific gravity, urine osmolality and creatinine increased, and urinary pH decreased. Serum creatinine, uric acid and urea nitrogen increased, while chloride and potassium decreased. Pre-shift serum uric acid levels were remarkably high and pre-shift eGFR was reduced (<60 mL/min) in 23 male workers (14%).

CONCLUSIONS: The high prevalence of reduced eGFR, and the cross-shift changes are consistent with recurrent dehydration and strenuous work in a hot and humid environment as the primary causal factor. The pathophysiology may include decreased renal blood flow, high demands on tubular reabsorption, and increased levels of uric acid.

Long-term cognitive problems after toxic inhalation incidents

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OBJECTIVES:

In agriculture there is a risk on toxic inhalation incidents through short but high exposure, e.g. to manure gases or pesticides. Both fatal and non-fatal cases occur and their emergency management is well described and strongly debated in the literature. But relatively few attention is given to the potential long-term neurotoxic health effects, although the risk of toxic or hypoxic damage to the nervous system is considerable, even after a latency period. We aimed to study long-term neurotoxic sequelae of toxic inhalation incidents with a focus on neuropsychological effects.

METHODS:

We reviewed the literature on long-term neurotoxic sequelae of toxic inhalation incidents and studied possible neuropsychological sequelae in a small group of workers evaluated after a toxic inhalation incident. These patients were evaluated through neuropsychological testing by the Dutch Solvent Teams because of persisting health problems. They had been exposed to either manure gases, hydrogen sulphide or some sort of pesticide.

RESULTS:

As expected from the literature, we found substantial cognitive defects in several cognitive domains in a subset of the evaluated patients. More often when the patients already experienced severe health problems immediately following the toxic exposure. A causal relation with the neurotoxic exposure seems probable, although it is not easy to rule out the influence of other factors, such as the psychological impact of the toxic inhalation incident.

CONCLUSIONS:

Toxic inhalation incidents may pose a substantial risk on long-term neuropsychological health problems. A more structured follow-up of workers who suffer from cognitive problems after acute toxic exposure is warranted. Further research is necessary to clarify the biological pathways and determine if and how psychological factors influence presentation and final outcome of these long-term sequelae.

Incidence Rates of Pelvic Organ Prolapse in Female Agricultural Workers in Japan

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OBJECTIVES

We conducted a questionnaire survey to clarify incident rates of pelvic organ prolapse (POP) and its' risk factors in female agricultural workers in Japan.

METHODS:

The subjects were selected from female members of the Japanese Agricultural Cooperatives aged 20-89 yrs. Main items of questionnaire were as follows; incidence of POP and POP related symptoms, numbers of child births, experiences of agricultural works and/or daily activities with abnormal abdominal pressure, etc. Cross tabulation and age adjusted logistic analysis were performed.

RESULTS:

The total subjects were 8407 (61.1±11.4 yrs.); among those, 34.3% for full-time farmers, 13.9% for part-time farmers and 51.8% for other occupation, housewives or no occupation (other group). The incidence rate of POP was 6.0% for total subjects; 6.4% for full-time farmers, 6.5% for part-time farmers, and 4.9% for other group. Significant higher incidences were seen in full-time and part-time farmers than other group ($p<0.001$ per each). The subjects with experience of abnormal abdominal pressure at least one time in a week were seen higher in the group with POP than those without POP ($p<0.001$). Result of logistic analysis indicated significant high odd ratios were seen in the items such as with constipation (odds ratio to be 1.67, $p<0.001$), number of child births (1.32, $p<0.001$), having abnormal abdominal pressure (1.29, $p<0.001$), BMI (1.23, $p<0.000$) and age (1.16, $P<0.059$).

CONCLUSIONS

The present research revealed the incident rate of POP was to be 5.6% for female population in Japan, showing significant higher rate in agricultural workers than in non-agricultural workers and housewives. The significant high odds ratio were seen in such items of constipation, number of child birth, having abnormal abdominal pressure, BMI and age. The present results indicate newly view point must be introduced to make preventive measures for incidence of POP in agricultural workers.

Promotion and coordination of health surveillance in agriculture in Mantua province

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OBJECTIVES: We conducted a systematic data collection which had the objective of describing, from epidemiological point of view the health status of a wide group of agriculture workers of a large agricultural territory in the North of Italy and evaluating the adherence of health surveillance protocols proposed by occupational physicians to those suggested by the Guidelines of Regione Lombardia published in 2009

METHODS: Medical history, including information regarding exposure to specific risk factors and fitness for work, was systematically collected from occupational physicians using a specific questionnaire submitted to 916 agriculture workers of the province of Mantua, during medical examination between March 2014 and March 2015. Data were subsequently processed by the Local Health Agency of Mantua and statistically elaborated by the Occupational Medicine Department of Cremona.

RESULTS: Agriculture has particular characteristics which can make difficult to perform health surveillance, comparing to other productive sectors and considering that most of the farms are family-owned, for which health surveillance in accordance with Legislative Decree 81/08 is currently on voluntary basis. There is also high fragmentation of the production on the territory, due to the reduced size of the farms. The collaboration of occupational physicians allowed us to investigate the health status of employees and seasonal workers that represent a small proportion of the population working in Italian agriculture sector. Based on information regarding health surveillance and fitness for work, it is also possible for us to say that health effects on agricultural workers coming from exposure to different risks that can be found in the production cycle remain still widely underestimated.

CONCLUSIONS: The activity provides a description of agricultural workers health status and represents a single experience in this field. This study offers a model for conducting in the future experiments that are aimed at increasing awareness of the need for health surveillance in agriculture.

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Exposure to organic dusts in rural settings

Organic dust contaminated with LPS is still the predominant exposure in animal breeding operations

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A recent study (Basinas et al. 2015) have reviewed the literature during the past 30 years.

In spite of several studies showing clear adverse effects of this type of organic dust on the health of farmers, not much has happened with the exposures in farming over this time period.

The farming occupation is characterized by a large day to day and individual differences in exposure due to job tasks and type of animals.

The dust levels in farms seems to be independent on time trends unlike what is seen in other types of industry.

We need to focus on the sources of exposure within farming in order to ensure a healthy working life among livestock farmers, and the newest literature seems to point towards possible targets for preventive interventions.

Quantifying Farmers' Exposure to Respirable Grain Dust while Performing Work around Grain Bin Storage Facilities

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Objectives

1. Determine time-weighted average (TWA) of respirable grain dust exposures for workers while unloading and cleaning grain bin storage facilities
2. Identify external variables that affect workers' TWA exposure
3. Determine prevention capacity of the N-95 respirator as adequate protection from grain dust

Methods

Ohio farms participated in a feasibility study whereby respirable dust samples were collected while farmers unloaded and cleaned their grain facilities. Air samples were collected using a battery-operated personal sampling pump with pre-weighed 37mm PVC cassettes filter cassettes. Farmers wore pumps 30 - 90 minutes while unloading grain, and 90 – 180 minutes while cleaning the bin. Workers were monitored for a 3-month period (June, July, August). Analysis for total respirable dust was calculated using gravimetric determination and compared to the NIOSH permissible exposure levels.

Variables were recorded during data collection: commodity type (soybeans or corn), moisture content of commodity, external weather temperature/humidity, and method of cleaning (auger, grain vacuum, shovel, etc).

Results

Data collection is currently ongoing. The following hypothesis are being confirmed:

1. Workers in grain bins are exposed to 50% of the U.S.'s permissible exposure level for total respirable particulates. The 50% level is critical because at this level (or higher), prudent safety management practices require workers to enroll in medical surveillance programs.
2. Cleaning grain bins with mechanized equipment generates more grain dust of the respirable size; likewise, bin design and size (bushel capacity) contributes to workers' exposure.
3. Efficacy of the N-95 respirator is suitable for use during grain bin unloading and cleaning activities.

Conclusions

This research was conducted to better understand the respirable dust exposure of farmers while working around grain storage facilities. Currently, farmers are recommended to wear N-95 respirators. This analysis project will confirm these recommendations, and increase farmers' awareness they are at risk of respirable dust exposure.

Prevalence of chronic respiratory symptoms, lung function impairment, and airway responsiveness - comparison between cow breeders and crop farmers

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Objective: To evaluate the frequency of respiratory symptoms, lung function test abnormalities and non specific bronchial hyperresponsiveness (BHR) among crop farmers and cow breeders, in relation with their severity and work-relatedness due occupational risk factors and farming characteristics. **Methods:** A cross-sectional survey was performed including 70 cow breeders aged 22 to 63 years (mean age=47.5±11.8; duration of exposure 23.1±9.6), compared to an equal number of crop farmers matched by age, job exposure duration, and smoking status. We have used a questionnaire to assess the chronic respiratory symptoms, detailed work history, specific farming activities performed, and smoking history. Evaluation of examined subjects also included lung function spirometry tests, and bronchial hyperresponsiveness testing (PC20≥8 mg/mL). Exposure type, frequency and intensity in both groups were recorded by job exposure matrices. **Results:** Cow breeders had a significantly higher prevalence of cough (31.4%), phlegm (17.1%), wheezing (12.8%), and nasal symptoms (21.4%) than the crop farmers (p<0.05). All spirometric parameters (FVC, FEV1, FEV1/FVC%, MEF75, MEF50, and MEF25) were lower in cow breeders compared to the crop farmers, but statistical significance was confirmed only for MEF25, MEF50, and MEF25-75 (p=0.03, p=0.04, and p=0.005; respectively). The prevalence of non specific BHR, defined by histamine PC20 less than 8 mg/mL, was higher in cow breeders but without reaching statistical significance (21.4% vs. 15.7%). Cow breeders exposed more than 15 years had more severe adverse chronic respiratory symptoms and lung function decline. The risk of developing work-related respiratory symptoms increased significantly with full-time farming, exposure to gases and vapors, and more than 20 years of workplace exposure. **Conclusion:** Our results indicate that occupational exposure in cow breeders plays an important role in higher prevalence of chronic respiratory symptoms, lung function impairment, and development of airway responsiveness.

Key words: respiratory symptoms, farming, lung function, questionnaire, airway responsiveness.

Exposure to organic dust in a farrowing-weaning farm as a possible risk for human and pigs: One Health Approach

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Objectives

Particulate matter, represents an important aerial contaminant in piggeries. A correlation between exposure to inert dust and disorders of respiratory function has already been demonstrated ^(1,2). Our study aims to quantify the concentration of airborne dust in a farrowing weaning room, in order to evaluate the risk odds of manifesting respiratory diseases for workers and animals.

Methods

The concentration of Total Suspended Particles (TSP) and the Respirable Fraction of dust (RF) were measured in a farrowing-weaning room of a piggery located in Northern Italy. A 2-stage Lippman cyclone separates the dust particles, captured by a nitro-cellulose membranes. The environmental parameters (temperature, relative humidity and ventilation rate) were also measured.

Measurements were taken at day 0, 15, 30, 60 and 75 at three different measurement point (near the entrance, in the middle, at the end of the room). The membranes were collected every 30 minutes during each sampling day.

Results

Concentrations ($\text{mg}\cdot\text{m}^{-3}$) of TSP and RF in the room were reported in the following table (mean value of 24-h).

Sampling time (d)	TSP	RF
0	0.081	0.013
15	0.310	0.108
30	0.745	0.375
60	2.970	1.050
75	3.200	1.630

In human health the thresholds for inert PM and organic dust are $10 \text{ mg}\cdot\text{m}^{-3}$ and $4 \text{ mg}\cdot\text{m}^{-3}$ respectively ⁽⁵⁾. The maximum PM concentration found in this piggery is above those thresholds. However, the current exposure limits can result to be barely protective, since even low exposure to dust with low reactivity or pathogenicity can lead to respiratory adverse effects. Allergen molds, bacteria, viruses are the major causes of respiratory problems both in human and animals. No dust characterization was conducted here, and an in depth analysis would be required to identify and quantify the “organic load” of dust.

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Environmental Health in Rural Areas

Across the globe: Healthy Farmers, Healthy Farms —The Sustainable Farm Families Project

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Background

A global issue facing agriculture is the health of its people. Farmers are ageing, working longer, and experience illness, injury and suicide at high levels. Family members also provide the labour needed to cope. In Alberta, farming is one of the most hazardous occupations and farmers are difficult to engage in health, wellbeing and safety issues.

The Sustainable Farm Families (SFF™) project was developed in 2003 in Victoria, Australia by health care providers, producer-groups, industry, and researchers to address health disparities. In June 2013, three representatives from Alberta, Canada travelled to Australia to investigate the SFF™ program, which had been successfully delivered to over 2300 farmers.

Methods

Theoretical frameworks from agricultural extension, health promotion, adult learning and behaviour change support the SFF™ model. In 2014 the Farm Safety Centre (FSC) received government funding to undertake SFF™ with Albertan farmers. A 5-day train-the-trainer workshop was held in Raymond, Alberta to train the nurses and agricultural facilitators in SFF™.

Results

SFF™ Alberta delivered 4 SFF™ workshops to 42 farmers from diverse operations. Participants were aged 26-76 years, 74% were male. An independent evaluation reported “The SFF Alberta workshops were theoretically consistent with SFF Australia.” . Numerous health issues were detected, and farmers rated the SFF™ program very highly. Health indicators and risk factors from the year 1 pilot will be presented.

Conclusion

The FSC successful delivery of SFF™ illustrates repeatability and transference of SFF™ internationally and the opportunity to address farmer health globally through an evidence based program.

Mesothelioma and sinonasal cancer risk in agriculture

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OBJECTIVES: To identify malignant mesothelioma (MM) sinonasal cancer (SNC) cases and to describe sources of exposure to asbestos and other carcinogens among workers of the agricultural sector in Lombardy.

METHODS: Lombardy Region (North-West Italy) is covered by a MM registry (since 2000) and by a SNC registry (since 2008). The registries collect incident cases of these kind of cancers in people living in the region. Exposure to carcinogens (asbestos, wood and leather dusts, nickel and chromium compounds) is evaluated through a standardized questionnaire administered to the patient or next-of-kin. MM and SNC cases with carcinogen exposure exclusively in the agricultural and breeding sectors have been extracted from the registry database.

RESULTS: Out of 4680 incident MM cases recorded in the period 2000-2014, sixteen subjects (15 with pleural, 1 with peritoneal MM; 13 M, 3 F) have had a significant exposure to asbestos while performing rural activities. Median age was 69.6 (56.8-79.3) years, with length of exposure of 36.5 (4-52) and latency of 52.3 (33.8-65.7) years. Seven subjects had been exposed during maintenance activities of asbestos-cement roofs or asbestos brakes of the tractors; 7 used recycled jute bags for feed or cereals that previously contained asbestos; 1 used asbestos filters during wine production; 1 had been working in fields near a factory of asbestos ropes. Out of 337 SNC cases recorded from 2008 to 2014, 1 woman with squamous cell carcinoma of the maxillary sinus was identified. She was 59 years of age at diagnosis and had been exposed to wood sawdust for 2 years in a turkey farm. The latency period was 30 years.

CONCLUSIONS: Occupational cancer occurrence in agriculture is usually overlooked. Our findings suggest that a small but significant number of cancers do occur even in this economic sector, in particular from asbestos exposure.

Improving the professional competency of Health Professionals – locating the ‘lost tribe’ in Farm Family Health

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OBJECTIVES:

This evaluative study follows on from previous work of Brumby and Smith (2009) and sought to understand if training and extension provided in working with farming men and women in rural Australia can lay claim to a broader and richer understanding of the health complexities of farm families. As well as improving and enhancing aspects of professional development of health professionals especially nurses. The Sustainable Farm Families Train the Trainer (SFFTTT) model is a 5 day national program designed by Western District Health Service, Hamilton, Victoria, Australia to enhance practice amongst health professionals working with farm families. Nurses completing this program are then supported to deliver the Sustainable Farm Families program in their communities.

METHODS:

This study revisited a diverse cohort of trained SFF health professionals who were trained over a five year period. A total of 120 Health professionals who completed the training were surveyed in order to discover how they had utilized knowledge and extended skills learned in the training and delivery of health education to farm families.. The responses were analysed and themed in order to create a deeper and more extensive understanding of the diversity and range of extended practice of health professionals.

RESULTS:

The results from this study highlight the unique effect that farm family focussed training has had on nursing practice for those nurses who have engaged with both the initial training, and the delivery of the program in their own health service and the health professional’s interpretation of enhanced practice in terms of their developing confidence and competence.

CONCLUSIONS:

Providing a more comprehensive understanding of the intricacies of this area of practice may have a subsequent impact on farm families across Australia through more appropriately trained, and culturally competent health professionals. Until now nurses likened the farm family to the ‘lost tribe’ when seeking ways to engage them in health promotion action.

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Factors affecting sustainable solution for treatment of waste water treatment or small villages in the West Bank (Palestine)

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BACKGROUND: Small scale agriculture is still a main source of income and substantial food supply for many inhabitants living in villages in the semi- arid area of the West Bank (WB). Thus, in the past, several foreign agencies have tried to assist these villages in building waste water treatment systems (WWTS) in order to permit re-use of the effluents and prevention of environmental and health hazards. However, many of the systems either do not work or are poorly maintained.

OBJECTIVES:

1. To evaluate the current state of operation of WWTS in a sample of small villages in the WB.
2. To try and elucidate factors affecting success or failure of implementing these systems in the villages.

METHODS: A survey of a sample of villages was conducted, using a standardized questionnaire for interviewing various stake holders in the operation of the WWTS.

RESULTS: In most villages the first stage of treating WW is by a household septic tank. The effluents of the tank are, as a rule, discharged directly to a close-by creek, even in villages where communal WWTS exist, in many cases because of financial constraints.

In villages where the WWTS utilizes wasteland technology the systems operate continuously for many years. However, no further use is made of this scarce commodity. In contrast, in villages where anaerobic and or aerobic systems were built, most of them are either not functioning or poorly maintained, leading to limited possibilities of use of the effluents.

CONCLUSIONS: In order to provide a village with a sustainable WWTS that functions properly , factors such as participation of the villagers and the municipality, technical, professional and financial support, should be developed and guaranteed in advance, in order to provide effluents of high quality that can be used for intensive crops production for extended periods of time.

Tremolite asbestos exposure in a rural area: personal sampling campaign results

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Background

Rural areas on the Calabro-Lucano border, Southern Italy, are characterized by the presence of ophiolites outcrops containing tremolite. A study mapped the outcrops and assessed the exposure through environmental sampling of airborne asbestos fibers nearby towns, showing doses up to 22 ff/L.

Our study assesses the presence and level of personal exposure to inhalable asbestiform fibers in residents employed in occupational activities involving earthmoving and soil disturbance and other activities.

Methods

We recruited 30 volunteers including 20 employed in construction and agriculture and 10 employees working in other sectors not involving disturbance of the soil, and also five relatives of patients who died of pleural mesothelioma residents in areas with ophiolites outcrops.

Sampling was conducted over two days later in the summer.

The content and type of asbestos fibers were determined by technique of scanning electron microscopy (SEM) equipped with EDS (Energy Dispersive Spectrometer).

Results

The SEM analysis showed the presence of asbestos fibers serpentine type tremolite in 20 above 30 filters obtained by personal sampling. EDS microanalysis allowed to exclude titanium and organic material. The doses of tremolite fibers observed were between 0.8 and 23.06 ff/L. The environmental fund limit of 2 gg/L was exceeded in 50% of samples. 60% of farmers reported a personal exposure than 2 ff/L (from 2.07 to 23.06 ff/L) and 100% of construction workers (from 4.02 to 12.02 ff/L).

The five relatives reported exposure values from 0.8 to 6.07 ff/L, exceeding in three cases the limit of 2 ff/L.

Conclusion

90% of residents not employed in agriculture and construction has been exposed to doses of tremolite lower than the value of the fund.

The information campaign, aimed at a proper risk management, was useful. Health surveillance of resident population is needed.

Zoonoses in agriculture and rural areas

Hepatitis E virus infection in rural health: an emerging occupational risk?

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OBJECTIVES: Hepatitis E virus (HEV) infection is endemic in many developing countries, causing substantial morbidity. Transmission is primarily faeco-oral and is associated with both sporadic infections and epidemics in areas without drinkable water. In industrialised countries, HEV infection was thought to occur only in individuals infected in endemic areas. However, sporadic cases have been reported in persons from industrialised regions with no history of recent travel. Such reports and the availability of more comprehensive molecular and serological data have changed HEV epidemiology, accepting that autochthonous HEV is a problem in industrialised countries. Recently it has become clear that HEV is also an endemic disease in industrialised countries. Moreover, a porcine reservoir and growing evidence of zoonotic transmission have been reported in these countries, suggesting the possibility of occupational transmission to man. This review summarizes the current knowledge on the epidemiology and prevention of transmission of HEV infection in occupational settings

METHODS: The following keywords were used to explore PubMed: hepatitis E, disease, epidemiology, profession(al), occupation(al). The results were further screened and 107 publications were retained.

RESULTS: In nonendemic regions, seroprevalence varies from a few percent (2-7.8%) in Europe, Japan and South America to several percent (18.2 – 20.6%) in the USA, Russia, UK, southern France and Asia.

A meta-analysis of 12 cross-sectional studies evaluating potential association between HEV IgG seroprevalence in individuals occupationally exposed to swine showed greater odds of seropositivity in the exposed group but also a high degree of heterogeneity. The funnel plot suggests publication bias

CONCLUSIONS: There is a significant association between occupational exposure to swine and HEV IgG seroprevalence, but the level of prevalence detected depends also on the type of HEV IgG kits used. Further research, including on mechanisms and risk factors for infection, as well as the development of better serological tests for identification of infection, are required.

Zoonotic Pathogens are Occupational Hazards to US Livestock & Poultry Workers

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OBJECTIVES:

US food animal workers include those who raise, slaughter, and process animals for food. Those in processing are in a unique position in occupational health, due to their risk of exposure to zoonotic pathogens, and their subsequent risk of transmission of infection to other food products, as well as to their family and community members. Animals often arrive for slaughtering and processing contaminated with zoonotic pathogens, putting workers at risk for injury and infection. Currently, federal agencies such as the Occupational Safety and Health Administration (OSHA) and the National Institute of Occupational Safety and Health (NIOSH) do not consider these zoonotic pathogen exposures occupational hazards, leading to little data on the details of these risks.

Infectious skin diseases have been found to be the most common skin condition among Latino manual workers in North Carolina. Similar animal manufacturing industry settings have shown high rates of worker injuries and infections, such as the US pork industry, Chinese pork industry, and European poultry industry.

METHODS:

Currently no US standards or guidelines exist for surveillance of zoonotic pathogen exposure in livestock and poultry processing workers. Legal issues, such as undocumented worker status, complicate the reporting of injuries or dangerous working conditions. We outline a strategy to protect these employees by a series of: (1) coordinating with relevant stakeholders, (2) requesting that NIOSH complete a health hazard evaluation program of high risk plants, (3) crafting a model surveillance program, and (4) supporting the adoption of this model surveillance program via employers and union contract negotiators.

RESULTS and CONCLUSIONS:

Are forthcoming.

The prevalence of zoonotic chlamydial infection in farmers of Kyrgyzstan

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INTRODUCTION: Zoonotic chlamydial infection caused by *Cl. psittaci* is widespread in the animal world and characterized by persistent course and severity of disease in humans, and by high cost of expenses for carrying out anti-epidemic measures. In Kyrgyzstan, the prevalence of the infection in sheep was studied, but the prevalence in humans is not studied yet.

The aim of the study was to estimate the prevalence of persistent infection caused by *Cl. psittaci*.

METHODS: In 2002-2009, 420 farmers entered the Republican Clinical Hospital with suspected brucellosis is examined. ELISA is used to detect IgM and IgG-antigens in serum and polymerase chain reaction (PCR). Statistical analysis is done using EPI INFO.

RESULTS: Antibodies to *Cl. psittaci* were detected in 258 patients. Of these, 54.3% had antibodies to the antigen only *Cl. psittaci*, indicating for mono-infection of generalized zoonotic chlamydial infection. 118 patients (45.7%) had antibodies to antigens *Cl. psittaci* and brucella, indicating mixed infection. Analysis showed that the risk groups are persons of active working age - 20-40 years old, who made up 52% at chlamydial mono-infection and 63% at mixed infection.

Analysis of the data showed that brucellosis and chlamydial mono-infection are distributed in all regions of Kyrgyzstan. It was found 41% of patients with mono-infection had foodborne infection and 57% had contact transmission, and patients with the mixed infection in 80% of cases had contact transmission.

CONCLUSIONS: Studies have shown relatively high prevalence of chlamydial infection among the farmers in the country. There is a need for effective control measures to identify the source of the infectious agent and conducting complex measures to prevent further human zoonotic chlamydial infections and brucellosis among farmers and the rural population.

The level of tetanus immunity in the agricultural workers in Lombardy Region, North of Italy

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OBJECTIVES: Tetanus which is a vaccine preventable disease still is significant health concern and continues to take lives worldwide. From last decade, Italy had the highest rates of tetanus reported cases among European countries. The objectives of this study were assessment of the level of immunity against tetanus among agricultural (Italian/ non-Italian) workers of the Region and their knowledge regarding their previous vaccination.

METHODS: The study was conducted in agricultural enterprises covered with occupational health surveillance at the workplace in the region of Lombardy, Italy. Blood samples of 743 (481 Italian and 262 non-Italian) workers, were collected in the frame of Occupational Health surveillance activities in five provinces of the Lombardy Region and concentrations of antibody to tetanus toxin (anti TT) in sera were measured by an enzyme-linked immunosorbent assay. Meanwhile during the survey it was asked to workers if they remembered to be vaccinated against tetanus and also about the vaccination time.

RESULTS: In our survey nearly half of the Italian workers declared that they had vaccination (52.9%) versus 27.8 % of migrants. In addition, Italian workers had better tetanus Medium/ long term protection (79%) compared to non-Italian workers (54.2%) and this difference was statistically significant ($P < 0.01$, chi square test). Results of the multivariate regression showed among independent variables nationality and age were significant predictors ($P < 0.01$) regarding to dependent variable (anti TT titer).

CONCLUSIONS: This study supports the recommendations of including in any programme of health surveillance of workers the need of dealing with tetanus immunization, considering in particular migrant workers and the elderly, who might have not received a booster dose in time to maintain a good coverage. Even though the gold standard in the decision making process is represented by antibody titre determination, when this cannot be done, for example for seasonal and temporary workers, the performance of a booster dose is the most appropriate solution, able to ensure an adequate coverage.

The Status and Epidemiological Characteristics of Zoonoses in Korea

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OBJECTIVES: Zoonoses arise from infections transmitted from vertebrate animals to people. I aimed for understanding the scope and the epidemiological characteristics of zoonoses in Korea. I will introduce some seroprevalence studies in high risk groups of zoonotic diseases.

METHODS: I used the disease web statistics system of Korea Centers for Disease Control and Prevention. Also, I reviewed many articles and books about zoonoses in Korea.

RESULTS: Beginning with the first confirmed case of leptospirosis in 1984 followed by Q fever in 1992, Lyme disease in 1993, cryptosporidiosis in 1995, tularemia in 1997, enterohemorrhagic *Escherichia coli* in 1998, brucellosis in 2002, botulism in 2003, and severe fever with thrombocytopenia syndrome in 2013, several outbreaks were confirmed. Korea has suffered from reemerging diseases such as *Vivax malaria* along the Demilitarized Zone (DMZ) since 1993. In 2014, the number of incidences of zoonotic notifiable diseases was 8,130 cases with scrub typhus, 344 cases with hemorrhage fever with renal syndrome, 638 cases with malaria, 111 cases with enterohemorrhagic *E. coli*, 58 cases with leptospirosis, 55 cases with severe fever with thrombocytopenia syndrome, 9 cases with murine typhus, 17 cases with brucellosis, 26 cases with Japanese (B) encephalitis, 11 cases with Q fever and 13 cases with Lyme disease.

In the 14 years between 2001 and 2014, imported zoonotic notifiable diseases had 1,081 cases with dengue fever, 671 cases with malaria, 14 cases of Lyme disease, 5 cases of melioidosis, 3 cases of chikungunya fever and 1 case of West Nile virus.

CONCLUSIONS: Korea has experienced sporadic cases or outbreaks of emerging and reemerging zoonotic infectious diseases since the 1980s. No accurate statistics have been compiled on the prevalence of zoonoses in rural communities. More education about transmission and prevention of zoonoses is needed for Korean people, especially farmers.

Biological hazards among meat industry workers

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BACKGROUND

The Italian meat supply chain is a large-scale industry typically characterized linked to circuit of DOP (Protected Designation of Origin) products.

In this reality all workers are exposed to a wide range of biological agents that have developed antibiotic resistance and, therefore, represent a public and occupational health issue.

METHODS

An anamnestic semi-structured interview was performed to the study participants, in order to better define the risk exposure, which was followed by physical examination of the skin and skin appendages.

Samples of nasal swabs were sown, within 24 hours, in Mannitol Salt Agar growth medium, specific for the detection of *Staphylococcus Aureus*.

After an incubation period, we selected positive colonies for *S. aureus* in order to undergo genetic tests to detect the presence of MRSA.

MRSA positive samples were analyzed, at last, with a specific PCR for the ST398, swine specific sequence type.

RESULTS

162 workers joined the study, which was performed a physical examination of hand skin, a nasal swab and then given an anamnestic semi-structured interview.

The sample was composed of 139 males and 23 females, mean age 45 years, with average seniority of 10 years.

From 162 nasal swabs championships, a first analysis of culture media for *Staphylococcus Aureus* showed 35 positive (21.6%).

The molecular analysis revealed only one MRSA sample, belonging to a butcher's meat processing company. (0.6%).

The molecular analysis did not confirm the positivity for genotype 398, which characterizes the infection in pigs.

CONCLUSION

Recontamination with *Staphylococcus Aureus* occurs via surface treating machinery, as a result of fecal contamination at evisceration, or via increased human handling during meat processing.

Our study revealed a low risk for MRSA, because of superficial heat treatments such as scalding and flaming that reduce significantly the burden of MRSA on the carcasses.

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Case Study of Rural Village Isolation of MERS

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Objectives: When MERS (Middle East respiratory syndrome) was incident in 2015, a person in Jangdeok village got infected. This led the whole village to be kept in quarantine. This paper was analyze the health, social, economic, and legal problems that village had faced and would like to suggest solutions to them.

Methods: From 2015 June 5th to 19th, for two weeks, 102 village residents in one village were isolated and various problems occurred during this period. Those problems of various fields would be analyzed. Data and information used for the analysis is collected through the internet search and Korean news articles and New York Times articles were collected to get reviewed and analyzed. 23 articles on Jangdeok village's quarantine were selected and information got categorized into: process of the quarantine, problems that villagers faced during and after the isolation, and evaluation of the quarantine.

Results: Major problems that occurred during two weeks of isolation are as the following: 1) One confirmed patient was transferred to hospital to get treatment and villagers were thought to have had contact with MERS patient. For two weeks, villagers were told to stay at home and their temperature and whereabouts were checked twice a day. 2) As for the economic problem, income has decreased due to the quarantine. Villagers of Jangdeok make their living by farming and they could not work during the isolation period. Also, even though the village's agricultural products had nothing to do with MERS virus, people refused to purchase them and this led to decline in income. 3) At first, villagers did not get any economic compensation or support since the legal grounds to aid the village was not enough. However, individuals and NGOs donated more than one hundred million won to villagers. 4) Villagers were self-isolated in their home and therefore could not meet with neighbors. The ways for them to contact with the outside were mainly telephone, television, and doctors.

Conclusions: The quarantine has been cleared on June 19th without any further infection. This was possible due to devoted cooperation of villagers. Although the purchase of the village's farm produce once decreased due to the groundless distrust towards its safety, villagers were supported by local government and various private organizations. The community is rapidly going back to its original state. This is one of the successful cases of disease control.

WMSDs and Occupational Health

Agricultural machinery injuries in Finland 2004-2014

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OBJECTIVES:

Machinery is a major source of injuries in agriculture. The “Koneturva” [machinery safety] project assessed injury risks related to agricultural machinery. We aimed to describe the characteristics of injured persons; circumstances, work activities, and sources associated with the injury events; as well as lost time and cost of machinery injuries.

METHODS:

We obtained claims information from the Finnish Farmers Social Insurance Institution (Mela). The data covered a ten-year period, Jan 2004 –Sep 2014. During this time, the number of farms reduced from 63,847 to 50,201, and the number of insured farmers reduced from 92,569 to 70,448. Frequency distributions of the variables were calculated and additional information was obtained from injury descriptions.

RESULTS:

The estimated number of all injuries to farmers during this time was 56,000. The number of injuries caused by machinery was 11,327. During the 10-year period, the proportion of machinery injuries grew from 19% to 24%. The average compensation amount of machinery injuries was 3796 Euros per case, and the average disability duration was 32.6 days. While 33% of the farmers were women, only 8.6% of the machinery injuries occurred to women. Nearly 1/3 of the injuries happened during maintenance and repair of machinery. Age, years farming, farm income, incident date and time, work activity during incident, type of machine involved and other variables were analyzed from the 11,327 injury cases.

CONCLUSIONS:

Injuries can be prevented by effective guarding and safety devices, and limiting the use of older unsafe machinery. Attention to safety in the design of new machinery and safety information given to users in operator’s manuals and other communications is also important in reducing machinery injuries.

Common risk factors for agricultural injury

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OBJECTIVES:

The objective of this study was to review the available literature and identify common risk factors for agricultural injury.

METHODS:

We conducted a systematic review of research studies evaluating agricultural injury risk factors. Studies that reported adjusted odds ratio (OR) or relative risk (RR) estimates were identified from PubMed and Google Scholar. Pooled estimates were calculated for frequently reported risk factors using meta-analysis.

RESULTS:

A total of 441 studies were found in the PubMed searches. Of these, 132 met the selection criteria for injury outcomes, and 32 of these reported adjusted OR or RR estimates. Google Scholar searches yielded 285 studies; 78 met selection criteria, but all were already included among studies found in PubMed searches. One study was excluded as it did not meet our set Newcastle-Ottawa Scale quality criteria, and therefore 31 studies were used for meta-analyses. The pooled ORs for the risk factors were: male gender (vs. female) 1.68, full-time farmer (vs. part-time) 2.17, owner/operator (vs. family member or hired worker) 1.64, regular medication use (vs. no regular medication use) 1.57, prior injury (vs. no prior injury) 1.75, health problems (vs. no health problems) 1.21, stress or depression (vs. no stress or depression) 1.86, and hearing loss (vs. no hearing loss) 2.01.

CONCLUSIONS:

All evaluated factors except health problems significantly increased the risk of injury, and they should be: a) considered when selecting high-risk populations for prevention efforts, and b) considered as potential confounders in designing intervention studies.

Keynote lectures- 10th September 2015

The IARC Monographs, evaluations of the carcinogenicity of pesticides and on-going research

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The IARC Monographs identify causes of cancer in the human environment, including chemicals, mixtures, personal habits, drugs, biological and physical agents. Since its inception in 1971 the Monographs programme has evaluated over 950 agents, with more than 100 classified as carcinogenic to humans and over 350 as probably or possibly carcinogenic to humans. The process of causal inference used for IARC's evaluations is defined in the Preamble to the Monographs. International Working Groups of invited experts evaluate human, animal and mechanistic evidence and reach a consensus evaluation of carcinogenicity for each agent. First, human and animal cancer data are evaluated separately, with the weight of the evidence for causation being categorised as Sufficient, Limited, Inadequate, or Suggesting lack of carcinogenicity. For the overall evaluation of carcinogenicity, the Working Group considers the totality of the evidence and assigns agents to one of 5 groups: 1 Carcinogenic to Humans; 2A Probably carcinogenic to humans; 2B Possibly carcinogenic to humans; 3 Not classifiable as to carcinogenicity to humans, or 4 Probably not carcinogenic to humans. Mechanistic evidence has an increasing role in overall evaluations and strong evidence can be used to upgrade or downgrade an overall evaluation. The synopsis of procedures and strategic directions of the Monographs programme will be illustrated by an overview on evaluations of the carcinogenicity of pesticides with a particular focus on some recent evaluations.

Research gaps on carcinogenicity of pesticides can be addressed in AGRICOH, an international consortium of cohort studies of agricultural exposures. AGRICOH comprises more than 20 cohorts from 5 continents, with a broad definition of agricultural settings and exposures. The pooling of cohorts together with enhanced and harmonized exposure assessments allows to study cancer and other adverse health effects in association with a wide array of agricultural exposures.

UV induced Skin Cancer and Eye effects: neglected occupational risks!

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OBJECTIVES:

Solar Ultraviolet Radiation (SUVR) represents a well known, even if largely underestimated, occupational risk: more than 20 million outdoor workers are exposed in Europe.

SUVR exposure depends on various environmental and individual factors, such as atmospheric composition, geographic factors, meteorological conditions, type of surface, and individual characteristics, including behavioral.

SUVR can induce both short and long-term adverse effect. According to WHO, short-term effects include sunburns and photodermatoses in the skin, photokeratitis, photoconjunctivitis and solar retinopathy in the eye, and reactivation of latent herpes labialis infections in the immune system. Long-term adverse effects are photoageing, solar keratosis, non-melanoma and melanoma skin cancers in the skin, pterygium, cortical cataract and epithelial corneal and conjunctival cancers. As precursor to manifest skin cancer lesions in body areas directly exposed to the sun, chronic actinic damage will occur and should thus be objective to screening investigations in risk professions.

METHODS:

An overview of current knowledge, recently developed diagnostic tools, dosimetry and risk assessment will be given.

RESULTS:

So far, there are no sufficient health and safety regulations regarding solar UVR in Europe. The European Directive 2006/25/EC defines limits only for artificial UV (30 Joule/m² - effective radiant exposure/day): in outdoor workers (OW) these are very frequently exceeded, as shown by recent studies showing Standard Erythral Doses (SED) ranging from 6.11 to 28.6 SED (1 SED =100 J/m²) in farmers, construction and maritime workers.

CONCLUSIONS:

Considering the relevance of the risk related to SR exposure, further research on adequate methods to evaluate exposure, especially in OW, and on adequate preventive measures, is needed. An awareness campaign, directed at policy makers and the public is presently successfully putting this vastly neglected occupational risk on the map of work protection and prevention.

Biological monitoring of Pesticides Exposure in Rural Areas

Blood Cholinesterase Activities over Two Years among Latino Farmworkers in the United States: Pesticide Exposure Evidence and Health Implications

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OBJECTIVES: (1) To describe patterns of cholinesterase activities across the agricultural season, comparing migrant farmworkers and non-farmworkers; and (2) to explore differences between farmworkers' and non-farmworkers' likelihood of cholinesterase depression.

METHODS: Venous blood samples from 210 Latino male farmworkers and 163 Latino male workers with no occupational pesticide exposure collected eight times across two agricultural seasons were analyzed for whole blood total cholinesterase, acetylcholinesterase, and butyrylcholinesterase activities. Mean cholinesterase activity levels and depressions $\geq 15\%$ were compared by month, with the two years combined.

RESULTS: Compared to non-farmworkers, farmworkers had significantly lower total cholinesterase and butyrylcholinesterase activities in July and August, and significantly lower acetylcholinesterase activity in August. For total cholinesterase, farmworkers had almost four-fold greater odds of depressed cholinesterase activity in August and one and a half times greater odds overall, compared to non-farmworkers. For acetylcholinesterase, the pattern was the same. For butyrylcholinesterase, farmworkers had two-fold and three-fold greater odds of depressed cholinesterase in July and August, respectively, and more than one and a half times greater odds overall. Odds ratios were highest (3.13-3.8) in the month of August for each cholinesterase activity without considering recent residential exposures, and remained highest in August (2.8-3.33) when residential exposures were included in the model.

CONCLUSIONS: Baseline cholinesterase activities can rarely be established for migrant farmworkers, as their risk of exposure is constant. In the absence of acute poisonings, it is difficult to document exposure to non-persistent organophosphorus and carbamate pesticides. These analyses show consistent seasonal patterns of exposure over two years and significant contrasts with cholinesterase activities in non-exposed workers. This provides evidence that farmworkers experience pesticide exposure, despite US regulations intended to protect workers. As results from other studies show linkages of chronic, low-level pesticide exposure with neurodegenerative diseases, cancers, and other health outcomes, more effective protections for farmworkers are needed.

Comparison of persistent symptoms and cholinesterase levels in laborers in three stages of the agricultural process

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OBJECTIVE:

To identify differences between erythrocyte cholinesterase levels, hemoglobin and persistent symptoms in laborers in three stages of the agricultural process

METHODS:

Three studies were conducted in an agricultural company in northwestern Mexico. The first study was done at the beginning of the season. The second during the planting and pruning, each one included 106 workers. The third was held in the collection stage and included 172 workers. During the first baseline measurement of biological indicators were performed, a questionnaire was used to assess socio-demographic characteristics, diseases and 19 symptoms which have been associated with cholinesterase inhibiting pesticides. The symptoms were classified into: non-specific, probable and specific. We considered persistent, those who remained in the last 15 days. For the measurements two and three, the same procedures were repeated, further evaluation of working conditions and exposure to pesticides were added. SPSS for analysis was used.

RESULTS:

In the first, second and third measurement, there were significant decreases in cholinesterase and hemoglobin ($p < 0.001$), but there were within normal ranges. The prevalence of persistent symptoms was 37.7%, 51.8% and 62.2%, respectively, $p < 0.05$. There was an increase in the number of symptoms per worker. We didn't find statistical association between symptoms and cholinesterase levels, but we found it among symptoms, frequency of pesticides application, re-entry time, hours of work per week, use of personal protective equipment, work clothing change and shower after work day ($p < 0.05$). The risk of symptoms was 55% higher in the most exposed to pesticides workers.

CONCLUSIONS:

The increased frequency of persistent symptoms and their relation with exposure to pesticides and poor working conditions was evident. However, as has been observed in other studies, it was not associated with cholinesterase levels.

Health effects related to pesticide exposure and blood cholinesterase activity among elderly farmers in northeastern Thailand

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OBJECTIVES: The number of Thai elderly workers is increasing, especially agricultural workers. Elderly may be more sensitive to pesticides. However, studies on health effects related to pesticide exposure in elderly farmers are limited. This study aims to determine pesticide-related symptoms and blood cholinesterase activity among elderly farmers in rural areas.

METHODS: A cross-sectional survey was conducted in April 2015 at Huaruea Subdistrict, Mueang District, Ubonratchathani Province, the large agricultural area in the northeast that mainly cultivated chili. A total of 30 elderly farmers (aged ≥ 55 years) directly exposed to pesticides was recruited and interviewed. Blood cholinesterase (ChE) levels, including erythrocyte cholinesterase (AChE) and plasma cholinesterase (PChE) were measured with the Test-mate ChE (Model 400) ^[1]. For interpretation and treatment, if ChE levels were less than 50% of the normal value, it indicates abnormal level that means possible pesticide poisoning requiring removal from exposure and/or treatment. ^{[1] [2] [3]}

RESULTS: Farmers had an average age of 60.5 (± 7.3) years (age range: 55-83 years). Most were males (60.0%) and some had chronic diseases (20.0%). All of them grew chili and of 60.0% also cultivated various vegetables. Their working experience ranged from 5 to 40 years. They involved in mixing or loading (86.7%) and spraying pesticides (93.3%) as well as applying chemical fertilizers (100%). Most farmers reported using pesticides 2 times/month (53.3%). Common pesticides used were chlorpyrifos, profenofos and carbamates. About 36.7% farmers had adverse symptoms after working with pesticides (i.e. Headache, dizziness). The mean AChE and PChE levels were 2.65 (± 0.77) and 1.50 (± 0.58) U/ml, respectively. The prevalence of abnormal level was 46.7% for AChE and 36.7% for PChE.

CONCLUSIONS: Elderly farmers may get risk on AChE and PChE depression leading to pesticide poisoning. Provisions of medical monitoring programs and preventive measures to reduce pesticide exposure among elderly farmers are recommended.

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Urine and hair specimens for biomonitoring short and long term penconazole exposure

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OBJECTIVES:

Penconazole (PEN) is a fungicide widely used in vineyards. Objective of this work was the identification of urinary metabolites for biological monitoring of occupational exposure (1). We also assessed the ability to use hair matrix to evaluate long-term exposure to PEN.

METHODS:

Urine samples from 21 vineyard workers exposed to PEN during mixing and loading, application and re-entry were analyzed by LC-MS/MS to obtain a profile of candidate metabolites. Based on the presence of the triazole moiety in the full scan mass spectra major candidates were found. From their mass spectra hydroxy and carboxy-penconazole (PEN-OH and PEN-COOH), both as free molecules and as glucuronide conjugates, were identified (2). Urine samples were submitted to hydrolysis with glucuronidase to obtain the free chemicals, that were quantified. Hair samples of pre and post-exposure (PRE and POST-EXP) were analyzed. PEN in hair was desorbed with acetonitrile for 3 hours at 45°C and extracts were analyzed by LC-MS/MS.

RESULTS:

PEN-OH was the most abundant metabolite, with mean concentration about 3-fold higher (from 1.3 to 16.8) than PEN-COOH and a wide inter-subject variability. In investigated subjects mean levels in 24 h post-exposure urine samples PEN-OH ranged from 1.3 to 258 µg/L and PEN-COOH from 1.0 to 20 µg/L. Excretion of PEN metabolites increased with consecutive work shifts. Urinary metabolites were correlated with the potential and actual dermal exposure assessed measuring PEN on the work clothes and on the skin, with Pearson r up to 0.543. Median level of hair PEN were 0.010 and 0.060 ng/mg hair in PRE and POST-EXP samples respectively (p=0.005).

CONCLUSIONS:

Our results suggest that PEN-OH in post-exposure urine sample and hair PEN are promising candidate for biomonitoring short- and long-term exposure to PEN in agriculture workers.

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Biological Monitoring on Green house workers in Yazd Province, Yazd, Iran

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Abstract

Background and aims: Organophosphate compounds are the most popular insecticides with the widespread application in pest control. These toxic compounds interfere with the blood cholinesterase and inhibit the cholinesterase activity. Measurement of Cholinesterase activity is widely used for diagnosis of poisoning and adverse effects caused by pesticides. Green-house workers are one of the important occupational groups with the high risk of poisoning with organophosphate and karbamat pesticides. The purpose of this study was to assess the exposure of green-house workers with anti-cholinesterase toxic compounds by measuring the blood cholinesterase activity using electrometric method.

Methods: This research is a descriptive cross sectional study that carried out on farmers of the cucumber green-houses. In this study, 40 workers were selected and their blood cholinesterase enzyme activity were measured using electrometric method. In electrometric method the reduction of cholinesterase activity can be measured through recording the changes of blood pH induced by anticholinesterase agents. The results were analyzed by version 16 of spss software.

Results: Based on the obtained results the amount of erythrocyte cholinesterase enzyme inhibition was between 1.77% to 35.4% and the mean and standard deviation was $23.2\% \pm 9.68$. Similarly, the amount of plasma cholinesterase enzyme inhibition was between 1% to 28% and the mean and standard deviation was equal to 16.57 ± 7.92 . Following the analysis of results 25% (n=10) of the workers were identified with no poisoning, 17.5% (n = 7) with minor poisoning, 55% (n=22) with moderate poisoning and 2.5% (n=1) with severe poisoning.

Conclusion: Organophosphate poisoning has been reported as the third cause of poisoning and also the leading cause of poisoning deaths in our country. Therefore, considering the results of this research and the importance of the evaluation of workers exposure to organophosphate pesticides it can be stated that the use of electrometric method is a valuable tool for biological monitoring of exposed populations. As this method is simple, portable and not expensive and at the same time provides high precision, it has a potential to be applied for screening and early diagnosis of organophosphate poisonings in large-scale studies.

Keywords: Anti-cholinesterase pesticides, Biological monitoring, Green house workers, Occupational exposure.

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An ergotoxicological approach of exposure to pesticides in sheep breeding: (in)visibility of risks, workers representations and health issues

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OBJECTIVES: This study commissioned by the ANSES, the French Agency for Food, Environmental and Occupational Health & Safety, aimed to document the exposure situations occurring in sheep breeding when spraying pest control substances so as to identify the characteristics of exposure.

METHODS: Two different farms, differing in terms of size as well as practice were studied; an employee belonging to an Animal Health Watch Group (these groups are a network gathered in non-for-profit association whose objective is to monitor farm animal health through local members). Work situations presenting a direct exposure to the substance (dipping...) or potential indirect exposure through contact with animals (sorting lambs, shearing...) were identified. Systematic observations and films were made.

A visualisation technique using fluorescein was used so as to observe the areas exposed to the substance in the dipping process.

23 samples of hand rinsing water were collected following tasks that had been identified as likely to cause exposure to allow a quantitative analysis of exposure.

A self-confrontation interview was also carried out with each of the observed workers (4 in total) so as to analyse their practice in the situations likely to cause exposure.

RESULTS: The results reveal specific exposure situations that cause direct exposure in the dipping process as well as a potential chronic indirect exposure in daily activities that require contact with animals.

Many different exposure factors were identified at different levels: organisational, technical, behavioural (for the animals) as well as more associated to the workers themselves. Their representations on the risks they run have proved extremely influential on the exposing practices.

CONCLUSIONS: Although possibly not statistically representative, this study brings new information for the design of equipment, risk prevention and questions the processes that place pesticides on the market as well as the exposure models presently in use.

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Psychosocial health risk & workforce ageing

Health promotion for aged rural workers. The European study Prohealth65+

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OBJECTIVES: Europe has 12 million full-time farmers. Around 30% of them are older than 65 years. They continue to work on their holdings beyond the normal retirement age. Next to this people, but not mixed with them, there are migrant and seasonal farm workers, one of the most underserved and understudied populations in agriculture. Farming is one of the most dangerous occupations in Europe. Potential farm work-related health problems include accidents, musculoskeletal and soft-tissue disorders, pesticide-related illnesses, dermatitis, noninfectious respiratory conditions, reproductive health problems, climate-caused illnesses, communicable diseases, bladder and kidney disorders, eye and ear problems, cancer and mental health problems, including suicide. In addition, migrant and seasonal farm workers are exposed to health consequences of poverty, substandard living conditions, language and cultural barriers, and impaired access to health care. Few epidemiologic studies exist of these occupational health problems. Health promotion in agriculture is essential to ensure sustainability.

METHODS: Defining effective methods of promoting healthy lifestyle, identifying institutions and organizations which promote health of the elderly in Europe, and analyzing the general cost of health promotions activities, is the specific task of the study "Pro-Health 65+. Health promotion and prevention of risk - action for seniors" funded by the EU-CHAFEA. Within this framework, a comprehensive review of the literature helped to identify institutions and companies that actively promote the health of aged workers. At the end of the survey, an inventory of activities performed in the workplace in European countries will be available and will allow comparisons and choice of best suitable practices.

RESULTS: Preliminary results show that health promotion is much more practiced in services and industry than in agriculture. Health promotion methods targeted to rural aging people in Europe will be selected and analyzed in order to assess their impact on the health status of selected subgroups of the population (i.e.: migrants, women, ethnic or religious minorities).

CONCLUSIONS: Promotion programs targeted to increase age-related adaptations of healthy older adults, enhancing their experience and compensatory behaviors and information processing strategies, can minimize many age-related deficits and may allow older farmers to continue working safely and productively well past typical retirement age.

Emerging issues related to workforce aging and the EU ECapacit[∞] Project

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OBJECTIVES: The issue of an ageing workforce is true for a growing number of EU Member States and high on their political agendas. The European reality is that many employers and workers will soon realize that they will benefit more from working into their late sixties or early seventies, than they would from retiring before then. Apart from financial rewards, employment often gives one the chance to master new skills and achieve a sense of meaning. Fifty years of age is roughly the time, by which an average worker gains a handful of competences and practice. The general objective of the 'e-CAPACIT8' project is to strengthen the capacities of European occupational health professionals (OHPs), so that they can facilitate the process of workers' ageing. The primary objective is built on four specific objectives (SOs) and contains 7 work packages (WPs).

METHODS: The e-CAPACIT8 project was co-founded by the European Commission (the Consumers, Health, Agriculture and Food Executive Agency, CHAFFA), more precisely by the Health Programme of the European Union, and by each associated partner of the project Consortium for the project life-time spanning from February 2013 to May 2016. The project is co-ordinated by the Polish research institute – the Nofer Institute of Occupational Medicine – and involves associated partners from 13 countries. The project also involves national experts (Collaborating Partners) who support the project through their expertise.

RESULTS: During the project period the following deliverables related to the WPs were produced: two interim and final reports, Project promotional materials to include project start-up dissemination pack, stakeholders' database, Reports from the national workshops (In order to fine-tune all educational materials as well as promote other deliverables, the project team have organized a series of national workshops (one per country, including Italy). Draft and final versions of training materials, Beta and final version of the e-learning platform, End user survey and user commitments.

CONCLUSIONS: Expected outcomes of the project are as follows: Integration of OHPs into the contemporary practices of older (50+) workers' health protection. A forward-looking, under the "e-CAPACIT8" project, would be of interest to a multitude of national as well as international stakeholders. Providing specific educational materials (the e-learning platform) for OHPs from across 13 European countries to strengthen their capacities to improve the health of the ageing workforces. Improved quality of Stakeholder's (OHPs) daily encounters with older employees.

Alcohol-related morbidity in a rural area in Germany

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Background: Alcohol consumption accounts for a high burden of disease, in particular in rural areas. The population of West Pomerania in North-East Germany is characterized as a population at risk with a high prevalence of behavioral risk factors including alcohol consumption. This is reflected by a high proportion of patients being admitted to general hospitals due to alcohol-attributable diseases, but also by high levels of alcohol consumption and a high burden of disease due to subsequent morbidity including fatty liver disease (FLD) and hypertension in the general population. The aim of the present study was (a) to provide data on alcohol-attributable diseases in general hospital inpatients with alcohol problem drinking and (b) to investigate the association of FLD with hypertension in a general population sample.

Methods: We used data from a randomized control trial including data from 846 inpatients aged 18 to 64 years with alcohol problem drinking and data from a population based cohort study encompassing 3191 adults aged 20 to 79 years.

Results: Analyses showed that 46.8% of the general hospital inpatients had a disease attributable to alcohol consumption. Data from the general population study revealed that FLD was associated with hypertension at baseline and at five-year examination follow-up. For example, the chance of hypertension at both time points was threefold higher in individuals with FLD (OR 2.8, CI 1.3-6.2; OR 3.1, CI 1.7-5.8, respectively) compared to individuals without FLD.

Conclusions: In view of the high proportion of general hospital inpatients with alcohol-attributable diseases, a screening procedure for problem drinking is needed followed by appropriate intervention strategies. The results regarding FLD and its association with hypertension demonstrate that it is important to pay attention to alcohol-attributable diseases in the general population and that alcohol-attributable diseases are associated with subsequent serious sequelae.

Mentally challenging for farmers to apply advanced technology and automated systems?

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OBJECTIVES:

The project aimed to study how farmers and workers experience working with advanced technology and automated systems in their daily work. The hypothesis was that even though you have advanced technology and automated systems it is not necessarily equal to a good work environment, increased work efficiency and flexibility in the daily work.

METHODS:

The study comprised two farms with crop production and two farms with automatic milking in Southern Sweden. Ten people were interviewed on the four farms during the period from March 2012 to July 2013.

RESULTS:

In general, the interviews at the crop production and dairy farms focused on similar themes 1) Problematic and challenging technology 2) Difficult administrative systems 3) Large amounts of data information generated by the technology 4) The art and difficulty learning new technology 5) The availability of training and support 6) The value of operational safety and alarms 7) A work in change. The interview results showed that both the crop production and dairy farms had a high degree of mechanization. However, the machines, equipment and administrative systems were not as technically advanced as expected, and the participants did not use all the available operations. However, the interviewees considered that they used the most beneficial operations close to 100%. The interviews also revealed that advanced technological equipment and automated systems are seen as both an opportunity and a challenge. The technology allows for more accuracy and efficiency in daily work, it makes the work less physically strenuous and it gives more space for spare and leisure time.

CONCLUSIONS:

The challenges consisted in not compatible systems and programs and difficulties interpreting data. In addition, the technology can be complex to handle and operate. The technology can also be a mental strain when it is not working as expected. The nightly alarms causing disturbed sleep and a working day without an apparent ending were the most challenging for the dairy farmers and workers. However, machine or computer breakdown always disturb the daily work especially if you are short of spare parts or cannot get in contact with the service center.

Environment Safety, People Health Protection and Welfare

Poisonous bites and stings: a natural risk in the natural environment

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OBJECTIVES: To describe clinical aspects and medical management of poisonous bites and stings in farmers and fishermen. **METHODS:** A five years (2010-2014) retrospective study concerning the Pavia Poison Centre (PPC) experience on poisonous bites and stings in farmers and fishermen was performed.

RESULTS AND CONCLUSIONS: Outdoors occupational setting may expose workers to the risk of potentially venomous animal (bites/stings) and each activity has specific risks. In PPC experience, farmers and ranchers are the most commonly exposed to the risk of viper bite, while fishermen to the risk of venomous marine organisms stings (e.g. Trachinidae, Scorpaena, sea-catfish). Among snake bites, viper envenomation is the most considerable event and may be characterized by severe local/systemic symptoms with an estimated mortality up to 1%. In our experience, patients requiring antidote treatment were among 40%, and no fatal cases were registered.

In both categories (farmers and fishermen), hands and feet are the most injured parts of the body (the latter are particularly associated with stingrays); however, in the case of stingrays a chest injury was also reported. As pre-hospital management in cases of viper bites, the immobilization of the involved limb is indicated as general medical practice, while in case of Trachinidae stings specific treatment including hot water immersion and wound exploration are indicated. These treatments are effective in case of fish sting (but not when jellyfish or sea urchins and other invertebrates are involved) in addition to topical treatments, as antitetanus prophylaxis and antibiotics.

Rarely PPC managed patients envenomed by exotic animals, such as Agkistrodon bilineatus, Crotalus, Bitis parviocula and Botriechis schlegeli. These uncommon envenomations occurred in workers (e.g. herpetologists) and may require specific antivenom supply. PPC plays a key role in the clinical management of the envenomed patient.

Acute poisonings in farmers and fishers in Italy: a poison control center based 5 years case series /observation

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OBJECTIVES: To describe clinical aspects and medical management of human poisoning in rural and fishing occupational setting. **METHODS:** A five years (2010-2014) retrospective study concerning the Pavia Poison Centre (PPC) experience on poisoning in farmers and fishermen in Italy was performed.

RESULTS AND CONCLUSIONS: Outdoors occupational setting may expose workers to potentially toxic agents. In PPC experience, farmers and ranchers are commonly exposed to pesticides and herbicides. Inappropriate use associated with incorrect use of protective equipment may predispose to toxic exposures (skin/ocular contact, inhalation); clinical findings may vary from irritating symptoms to severe systemic manifestations. Clinical management may require cutaneous decontamination, symptomatic therapy and antidotal treatment; severe intoxications may need hospitalization. Rural setting may also expose to the risk of viper bites, that may be characterized by severe local/systemic symptoms with an estimated mortality up to 1%. Envenomation by exotic snakes is rare and may regard particular risk categories (e.g. herpetologists). Among veterinarians, occupational exposure are mainly characterized by accidental self-injection of veterinary medicine (vaccines, antibiotics, anesthetics/sedatives). Symptomatic and specific management of injuries at risk for rabies disease has been reported for particular outdoors occupational setting (e.g. foresters). Pneumonia caused by diesel fuel accidental aspiration is possible among farmers and may require medical evaluation and therapy with corticosteroid, antibiotic and oxygen supplementation. In PPC experience fishermen may be exposed to the risk of venomous marine organisms stings (e.g. Trachinidae, sea-catfish). In these cases, hot water immersion and wound exploration are indicated in addition to antitetanus prophylaxis and antibiotics (when required). Besides playing a fundamental role in the diagnosis of intoxication, PPC provides also a specialized advice to evaluate correct indications for antidote administration and to supply antidote in adequate amount. In occupational setting, a correct preventive information program may be essential and continuous training of physicians and workers is required.

Modelling exposure to pesticide in Rural Areas

Matphyto: a French program for retrospective pesticide exposure assessment by using CEM

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OBJECTIVES:

Acute effects of pesticides are well known, but information on delayed effects such as cancers is lacking. Detailed knowledge of past occupational exposures to pesticides is required for epidemiologic studies or monitoring survey. Retrospective assessment of occupational pesticide exposure is therefore challenging.

Up to now, no occupational pesticide exposure database exists in France and the existing databases do not provide an accurate picture to retrospective exposure to pesticides. Matphyto program has been initiated to remedy this knowledge gap. This program consists in developing crop exposure matrices (CEM) to pesticides to reconstruct historical pesticide use patterns in France

METHODS:

The Matphyto program aims at developing CEM for each French main crop since the 60s. Matphyto covers the metropolitan crops. Recently the program has been extended to the French overseas departments: Carribean Sea and Indian Ocean.

For each crop, data of the pesticide uses are collected and compiled. Different periods and geographical areas are characterized. Three exposure indicators for each active substance and chemical family are defined for each period and each geographical area:

- Probability (proportion of farms using a product),
- Frequency (average number of annual applications),
- Intensity (average dose used for one application).

CEM are validated by a group of agricultural experts and are freely available on the Internet.

RESULTS:

First, Matphyto focuses on the main French Crops: straw cereals, potatoes, corn and wine-growing. In parallel, population data are crossing with the CEM of arsenical pesticides. This work allows identifying occupational pesticide exposure indicators such as exposure prevalence of agricultural workers by sex, age, occupational period, region, etc. Moreover, CEMs can be useful to the occupational medicine as well as to epidemiological studies to assess more precisely pesticides exposure. Furthermore, a new project is currently launched to examine the feasibility to use Geographic Information System (GIS) to match the CEM with crop location data.

CONCLUSIONS:

Matphyto is a national program that covers most of the crops in France. The data will be widely and freely available to support assessment of occupational exposure to pesticides. First CEMs and first results of matrices combined with population data are already available.

CIA: a new tool to assess retrospective occupational exposure to pesticides in France

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OBJECTIVES:

The link between some chronic diseases such as cancer and pesticides continues to be contentious. One of the main issue is that measuring pesticide exposure is an enormous challenge in epidemiologic studies that rely on recall and retrospective exposure assessment. Over 1000 pesticides have been produced and placed on the French market since 1960 with various biological actions. No database gathered of the use of pesticides over time. With this concern and in response to a strong demand from researchers and public health managers, a new tool “Compilation des Index Acta (CIA)” has been developed. It aims at listing all the active substances which are registered in France since 1961, for all crops and all uses.

METHODS:

In France, Acta, the head of the agricultural technical institutes network, edits an annual index of plant protection products. This index details all registered active substances used in agriculture. The accuracy of data has been continually improved since 1961. In order to ensure continuous monitoring of the registered use of pesticides over time, a very important work of interpretation, homogenization and data input has been made. The choices made for homogenization were approved by experts from technical institutes.

RESULTS:

CIA provides data on pesticides as:

- 1053 individual forms (one form for each substance) with the characteristics and the agricultural uses of the substance,
- An Access® database which allows advanced queries about the active substance,
- Graphs from the main retrievals of the CIA database.

CONCLUSIONS:

This free tool, first of its kind in France, is available on web (<http://index-matphyto.univ-lyon1.fr>). CIA makes it possible to retrace the registered use of pesticides in France since 1961. Advanced queries from CIA database are possible according to the pesticides uses on crops, the approval and removal dates of an active substance, the chemical families... All these results improve the knowledge of the professional exposures history in agricultural sector, a required element for occupational health monitoring. This tool is useful to improve the traceability of farmer exposure carried out by occupational health doctors and to improve historical exposure assessment in epidemiological studies.

Biological Monitoring for Pesticide Risk Assessment in Farmers and Rural Population with a Tiered Protocol

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OBJECTIVES:

The assessment of exposure and of exposure-related risk for pesticides is a burdensome and expensive task. Since farmers are often exposed to many active substances, several times per year, at different working and environmental conditions, and their families, including children pregnant and breastfeeding women, the elderly, share the same environment, biological monitoring is the most promising technique for this purpose. However, there is still a difficulty to use the actual results of biological monitoring to assess individual risk, mainly due to the lack of suitable exposure limits.

METHODS:

To overcome this knowledge gap, the ICRH is currently establishing provisional Equivalent Biological Exposure Limits (EBELs) for priority pesticides. This multi-tiered approach exploits the extensive, although scattered information available in the scientific literature, in the authorization documents available from regulatory bodies, and the analysis of results from field studies.

RESULTS:

The established theoretical and computational basis and examples of the employed approach will be presented. In particular, it is possible to discriminate occupational exposure from agricultural tasks, including re-entry into treated fields, repair of agricultural equipment, from that of everyday life, from drinking water and from food. As proof-of-principle, the proposal of provisional EBELs for some priority pesticides, and an application to different agricultural tasks performed by Italian wine growers will be demonstrated.

CONCLUSIONS:

The establishment of a robust protocol for the determination of EBELs will allow individual risk assessment for farmers, for their families and for the general population of rural areas with moderate effort and cost.

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From Field Studies to Scenario-Based Risk Assessment: an Online Pesticide Risk Assessment Platform

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Risk assessment for applicators, among other categories, is required by law before an active substance is put on the market, and this process is usually done using the German model or the EURO-POEM. Nevertheless, real-life use of Plant Protection Products may differ substantially from the scenarios covered by the pre-market risk assessment, as many field studies have revealed, but pesticide exposure and risk assessment remains one of the most burdensome, expensive and rarely done activity in rural areas. Many scientific exposure studies have been done up to date, but their outputs and results are rarely used after the work has been published in scientific journals. At the International Centre for Rural Health (ICRH), we have been developing methods, namely “Exposure and Risk Profiles”, in order to use the pesticide exposure and risk measurements done by our institution for higher tier exposure and risk assessment without additional laboratory analysis.

Our studies are based on a standardized questionnaire developed at the ICRH specifically for this activity, as well as a collection protocol for personal and biological exposure monitoring. We standardized all our results to typical work-days’ exposure, controlling for work characteristics and personal protective devices.

Based on a study of 37 work-days of mancozeb application, we have developed exposure and risk profiles for closed (with air filters) and open tractor application. For mancozeb as the active substance, median risk was 0.12% of AOEL saturation, 0.10% for closed, and 0.28% for open tractors. Considering all use scenarios, the risk never exceeded 50% of AOEL saturation for mancozeb, and extrapolating to other active substances showed a risk only for substances with a very low AOEL together with high dermal absorption and use rate, most of which have been taken off the market.

We propose a multi-level, multi-tier approach. The first tier approach would offer risk assessment done using the German model. The user would then request the exposure and risk estimate using our field data (higher tier), adjusted of course, for the active substance of the user’s choice. As a final step, the user can receive an analysis of most exposed regions, as well as the preventive measures which could reduce the exposure the most, the multi-level analysis.

Education for Basic Occupational Health in Agriculture (2)

Education for Basic Occupational Health in Agriculture: a round table

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Introduction:

In different parts of the world courses on occupational health and safety have been developed, sometimes in the format of distant learning or blended learning. A growing amount of educational materials is available on the Internet and likely is used by teachers and students. It is worthwhile to evaluate these experiences. As the goal of WHO and OHLearning (OHTA) is the development of basic occupational health courses on a global scale, the question arises if it is possible to connect ideas and exchange experiences.

In this round table a first inventory of activities in this field will be presented and the possibility of support and exchange of educational materials will be discussed. Structure:

- Description of the training courses (target groups, content, structure) with referral to more detailed information
- Evaluation?
- Experienced key factors for success and failure.
- Possibilities for exchange of educational materials

Maybe a start can be made of a network of actors in this field. Workers Health in Agriculture could benefit from such collaboration.

Session 1

- Short introduction (Gert van der Laan)
- Kelly Donham (USA), experiences with training courses; lessons learnt
- Susan Brumby (Australia), experiences with training courses; lessons learnt
- Claudio Colosio (Italy) experiences from the International Centre of Rural Health
- Margherita Guzzoni (Italian Association of Workplace Safety Trainers) "Growing safety for workers and consumers.¹ A model for training and education in agriculture".
- Zeynep Şimşek (Turkey) a training Program for community health care staff
- Peter Lundquist (Sweden) experiences with training courses; lessons learnt

Session 2

- Maarten Verberk (LDOH), Development of a training program
- Tanja Perez Pavlisko (WONCA) on training book Rural Health
- Jorge Costa David (EU Commission), European experiences
- Shengli Niu (ILO) about WIND¹²-approach

Discussion:

- Experienced key factors for success and failure
- Mutual exchange of educational materials and support

- Translation of local agricultural practices in a training program
- Feasibility of an educational network; organizational issues
- Text proposal for a paragraph on this subject in the Lodi Declaration

Noise, Vibration, Dust, Endotoxin, Microorganism

Risk from vibration and noise on agricultural tractors

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OBJECTIVES:

The aim of this study was to evaluate the risk for operators of agricultural tractors and to identify risk-limiting interventions.

METHODS:

Tri-axial vibration on the seat's cushion and base as well as noise close to ears of the operator were measured on three agricultural tractors of different levels of technological progress. These tractors were examined during plowing, harrowing and driving both on a farm road and a paved road, at different speeds and at different values of inflation pressure of the tires.

RESULTS:

During plowing and harrowing, the frequency weighted acceleration values measured on the seat's cushion ($0.59 - 0.90 \text{ m/s}^2$) are such as to make exposure A(8) equal to the action value (0.5 m/s^2) after use for 2.5-5.7 hours/day. Concerning the tractor without the soundproof cabin, noise levels (92.2 - 93.5 dB(A)) are such as to make exposure (Lex,8h) equal to the action value (85 dB(A)) after use for 68-91 minutes/day. Regarding the two tractors equipped with a cabin, noise levels are lower than 79 dB(A).

During plowing, vibrations are higher than those measured when harrowing. On a farm road vibrations are much higher than those on a paved road. Generally, a decrease in the forward speed and a reduction in the pressure of the tires cause a decrease in vibration. Considering the horizontal axes, vibrations on the seat's cushion are higher than those on the seat's base; regarding the vertical axis, the seat can attenuate or amplify vibration.

The rankings of tractors in terms of vibrations are not always those expected.

CONCLUSIONS:

Vibration and noise on agricultural tractors can represent a risk for the operators. Noise must be limited with soundproof cabins. Sometimes the interventions to reduce vibrations are not easily identified.

Chemicals and agrochemicals in rural areas

Problematic of the pesticides use by the gardeners in Burkina Faso

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BACKGROUND: Pesticides are very useful in the field of gardening in the fight against pests, which exposes gardeners to the risks associated with their use.

OBJECTIVES: The aim of our work was to study the incurred risks by the gardeners in Ouagadougou, to bring them to adhere to the prevention strategies implemented for their health and safety.

METHODS: It was a descriptive exploratory and cross sectional study. The study population consisted of 101 vegetable growers coming from three districts. They were involved in a probabilistic way using a simple random sampling. The study was carried out from 25th February to 19th April 2013.

RESULTS: The majority of users were illiterate (66.3%). Their ages ranged between 21 and 69 years, with a median of 38 years. 78.2% was formed on pesticides by the Ministry of Agriculture. All vegetable growers used pesticides for most pyrethroids (86%). More than 90% products apply spray and keep the stocks in the fields. Personal Protective Equipment (PPE) was not worn. The empty containers were either buried in the ground or thrown into the fields. Damage the respiratory tract, eyes, and headache were the dominant symptoms after pesticide application. Finally, when the drinking water came from wells, it was not well covered in the majority.

CONCLUSIONS: With the strong urbanization and the increase of the demand, the gardeners were taken to big use of pesticides most of the time without follow-up nor control, with all the possible risks for their health, those of the populations as well as for the environment.

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- 99 - Investigating the impacts of endocrine disrupting compounds on sperm health: A new potential effect biomarker

Investigating the impacts of endocrine disrupting compounds on sperm health: A new potential effect biomarker

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Objectives: To describe how sperm aneuploidy is being used to assess the reproductive health effects of environmental and pesticide exposure.

Background: The WHO estimates that approximately 48.5 million couples experienced infertility in 2010. Each year more than 2 million couples in the US who want to have children are infertile, and over 2 million conceptions are lost before the twentieth week of gestation. About 40% of cases of human infertility are due to male factors. Errors in chromosome segregation during meiosis result in structural aberrations and imbalances in chromosome number known as aneuploidy. There is emerging evidence that environmental chemicals can adversely affect spermatogenesis and the occurrence of chromosomal aberrations, possibly through mechanisms of endocrine hormone modulation. The most common aneuploidies in humans at birth involve an abnormal number of X or Y chromosomes and at least 50% of XXY trisomies originate from the father. European data from consecutive birth studies show that the incidence of Klinefelter syndrome (XXY) appears to be increasing, but no increases have been observed in the incidence of XXX or XYY trisomies.

Methods: We have conducted studies of dichlorodiphenyltrichloroethane (DDT), polychlorinated biphenyls (PCBs), organophosphates (OPs) and pyrethroid (PYR) pesticide exposures and sperm aneuploidy in men recruited from clinics and communities. DDT and PCBs were measured in serum; OPs and PYRs were measured in urine. Sperm aneuploidy was analyzed using fluorescence in situ hybridization (FISH) to evaluate chromosome X, Y and 18.

Results: Recent data will be presented from investigations of exposures to persistent (DDT and PCBs) and non-persistent (organophosphate and pyrethroid insecticides) chemicals and associations with sperm aneuploidy to demonstrate the relevance of this endpoint for evaluating the endocrine disrupting properties of chemicals frequently used in agriculture.

Conclusions: Sperm aneuploidy is emerging as an important effect biomarker for evaluating the endocrine disrupting impacts of persistent and non persistent pesticides and related chemicals.

Pesticides intoxication

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OBJECTIVES: To describe clinical aspects and medical management of toxic professional acute exposures to pesticides and herbicides in farmers. **METHODS:** A five years (2010-2014) retrospective study concerning the Pavia Poison Centre (PPC) experience on toxic professional acute exposures to pesticides and herbicides was performed. Attempted suicides were excluded. **RESULTS AND CONCLUSIONS:** Pesticides and herbicide are professional products largely used in farmers and gardeners. There are many different molecules belonging to these categories of products and the toxic ways of exposures are highly variable (cutaneous and ocular contact, inhalation, oral contact). The identification of the risks relating to the specific products and the modality of acute exposure may delineate a various range of clinical manifestations that varies from irritating symptoms (e.g. lacrimation, cough, cutaneous hyperemia) to severe cases of systemic functional (e.g. cholinergic syndrome) and lesional damages (e.g. pulmonary fibrosis). Main intoxication predisposing factors are the inappropriate use of pesticides, associated with the incorrect use of Personal Protective Equipment (PPE). All potentially toxic contacts need a prompt medical evaluation. Focusing on organophosphates or carbamates poisoning, the clinical management may require cutaneous decontamination, symptomatic therapy and antidotal treatment, coupled with specialized laboratory support. Severe intoxications may need also hospitalization in intensive care units. Besides playing a fundamental role in the diagnosis of intoxication, PPC provides also a specialized advice to evaluate correct indications for antidote administration (doses and duration to treatment) and to supply antidote in adequate amount (e.g. oxime in case of organophosphate poisoning). To reduce potential risk of intoxication, especially in occupational setting, a correct preventive information program may be essential. Currently, always new molecules and associations of them appear on the market. In this frame, continuous training of physicians (in particular toxicologists) and workers is required.

Industry Point of View on Endocrine Disruptors

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OBJECTIVES: Discussion on State of Art of Endocrine Disruptors in Europe for Plant Protection Products's Authorization.

METHODS: Suspected increased incidences of some types of carcinoma, adverse effects on reproduction, diabetes and obesity are correlated to hormonal disfunction by some scientists. This has raised public concerns about chemical substances that could interfere with the endocrine system.

Although it is very difficult to ascertain whether and to which extent the daily exposure to chemical substances could influence the outcome or the severity of these diseases, the regulatory Authorities have considered to implement elements of a "cut-off" criteria system for substances which could interfere with the endocrine system into regulation. In the EU regulation of PPPs (EC 1107/2009) and for biocidal products (EC 528/2012) it is written, that substances, which have endocrine disrupting properties, cannot be authorized.

RESULTS: Taking the "cut-off" criteria into account, substances are approved on the base of their intrinsic properties, not considering the risk for human and environmental health on the base of the real conditions of exposure.

At the moment, the EU Commission is working on the definition of criteria to be used for defining a chemical substance as an ED and has performed a public consultation, that represents the impact assessment of the new legislation, which is the first step of the legislative tier.

CONCLUSIONS:

ECPA indeed agrees that there is a need to adopt criteria that are able to identify substances, which are likely to pose a human or environmental risk and precisely for those substances that give concerns under the real exposure conditions.

The criteria should be in accordance with the definition of endocrine disruptors from World Health Organization, they should be scientifically valid, unambiguous and applicable.

When assessing the ED effects of a substance, one should also take into account the adversity, the specificity, the severity, reversibility and potency (weight-of-evidence) for the endocrine-related effects and if it is likely that under real condition of exposure, the substance will reach concentrations (threshold) able to elicit adverse effect, at the proposed use rates.

Pesticide immunotoxicity: from *in vivo* evidence to mechanistic understanding

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Pesticides differ from all other chemical substances in that they are deliberately spread in the environment. Since they are designed to interfere with certain living organisms, variable levels of toxicity inevitably characterize them. Since this toxicity might be not specific for target organisms, pesticide use may endanger living species, including humans. It has been hypothesized that altered immune function may be an indicator of increased potential for the development of immunologically based diseases such as cancer, hypersensitivity and autoimmunity. In industrialized countries pesticides, together with new and modified patterns of exposure to chemicals, have been implicated in the increasing prevalence of such diseases.

Even if experimental data as well as sporadic human studies indicate that some pesticides can affect the immune system, overall, existing epidemiological studies are inadequate to raise conclusions on the immunotoxic risk associated to pesticide exposure. Xenobiotics may initiate, facilitate or exacerbate pathological immune processes, resulting in immunotoxicity by induction of mutations in genes coding for immunoregulatory factors, modifying immune tolerance and activation pathways.

The purpose of this presentation is to update the evidence of pesticide immunotoxicity and their mechanisms of action.

The Effectiveness of an Educational Intervention to Improve Knowledge and Perceptions for Reducing Organophosphate (OP) Pesticides Exposure among Indonesian Farmworkers

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OBJECTIVES: To determine the effectiveness of an educational intervention to improve knowledge and perceptions for reducing organophosphate (OP) pesticides exposure among Indonesian farmworkers.

METHODS: This was a quasi-experimental pretest-posttest study. Ethics approvals were obtained from Southern Adelaide Clinical Human Research Ethics Committee (SACHREC) with approval number: 319.13 and from Commission on Health Research Ethics, Faculty of Public Health, Diponegoro University, Semarang, Indonesia with approval number: 183/EC/FKM/2013. Thirty farmworkers working on conventional farms at Dukuhlo Village in Brebes Regency, Central Java, Indonesia received short information using power point slides followed by discussion. Knowledge and perceptions were measured using a structured questionnaire at baseline (pre-intervention) and at 3 months after the intervention. The resulted scores were analysed using paired t test.

RESULTS: Mean [SD] of scores of knowledge about adverse effects of OP pesticides exposure before and after providing intervention respectively were 14.17 [2.44] and 18.30 [3.39] ($t = 6.33$; p value < 0.0001). Meanwhile, scores of knowledge about self-protection from OP pesticide exposure in the first and second measurement respectively were 13.87 [3.34] and 16.17 [2.77] ($t = 4.70$; p value < 0.0001).

Scores of individual perception aspects (perceived susceptibility, perceived severity, perceived benefit, perceived barrier, and cues to action) were:

	Perceived Susceptibility	Perceived Severity	Perceived Benefit	Perceived Barrier	Cues to Action
Pretest	18.53 [3.93]	9.77 [2.06]	7.63 [1.83]	11.30 [3.52]	15.70 [1.37]
Posttest	21.93 [2.61]	10.73 [2.13]	8.53 [1.07]	12.73 [3.25]	12.73 [3.25]
t	6.02	3.38	2.34	5.58	1.69
p value	< 0.0001	0.0021	0.0264	< 0.0001	0.1022

CONCLUSIONS: This study suggests that the provided educational intervention can improve knowledge and perceptions to reduce OP exposure among farmworkers. However, cues to action did not significantly improve.

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Prevention of occupational skin diseases in agriculture

Contact allergy to the European Baseline Series in agricultural workers, 2009-2012

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At their workplace, farmers and other agricultural workers are exposed to a wide variety of substances, such as plant and animal allergens, microorganism, and pesticides, which may provoke occupational skin diseases. Most commonly, this is contact dermatitis, both allergic and/or irritant, at the site of frequent skin contact with irritants and sensitizing agents. The incidence of contact dermatitis is usually linked with the poor use of optimal protection (hat, boots, mask, gloves, impermeable coat and goggles). Evidence on farmers' skin disease is scarce, probably due to agricultural workers being less inclined to consult or possibly the incidence of occupational skin disease is indeed low in this group of workers. From this background, we examined data from European agricultural workers who were patch tested for suspected allergic contact dermatitis.

Material & Methods

We used data from ESSCA, 2009-2012, restricted to persons age > 15 and < 68 with a valid ISCO-88 code 6000 – 6999 who have been tested with the European Baseline Series (EBS). Data management and analysis is performed using the R software (version 3.1.0, www.r-project.org) following pertinent guidelines.

RESULTS

Among 29798 patients patch tested the percentage of farmers and fishers was very low (550 cases, 1.8%) with different percentages in involved counties: higher for Slovenia (7.16%) and Finland (5.9%), lower for Italy (0.87%) and United Kingdom (0.93%). Considering the job title the largest group was gardeners, horticulturists and nursery growers with 107 females (19.4 %) and 86 (15.5%) males; followed by skilled agricultural and fishery workers with 44 females (8%) and 38 (6.9%) males. Allergic contact dermatitis was demonstrated in the 52.2% of the group, 36.7% had irritant contact dermatitis, 8.1% presented other diseases. The most common involved sites were hands (50.2%) followed by head (14%) and arms (8.6%). Patch test sensitization in farmers was compared to those of white collar workers finding an increased sensitization to carbamates (6.92% vs 2.53%) and a significant lower sensitization to methyisotiazolinone (1.12% vs 3.14%, $p<0.05$), respectively.

Discussion and conclusions

Farmers are exposed to many substances that could cause allergic or irritant dermatitis: mainly pesticides and vegetables, but this professional group is underrepresented in analyzed countries data base patch tests. This could be related to the fact that farmers are less compliant to undergo patch tests than other professional groups. Moreover standard patch test showed an increased risk to be sensitized only to carbamates that are used as pesticides as well as rubber accelerators; and a lower risk to be sensitized to methylisotiazolinone, a hapten used in cosmetics. It must be noted that standard patch test is not sufficient to evaluate occupational dermatitis in farmers since many haptens are missing, such as vegetables or pesticides. For that reason there is the need to improve the diagnosis testing occupational series, to better define contact dermatitis in this professional group.

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Ultraviolence: sun induced occupational skin cancer

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BACKGROUND:

Surprisingly, solar ultraviolet (UV) radiation exposure is a vastly neglected occupational hazard. Recent large-scale meta-analyses have demonstrated that outdoor workers are least at a 43% higher risk for basalioma, and an almost doubled risk for squamous cell carcinoma. This poses challenges not only for the affected ca. 20 million outdoor workers in Europe but also to employers, social insurances, and health systems. Agriculture is one of the most UV-exposed branches. At EU level, it is of high relevance for the current Strategic Framework 2014-2020 for Health and Safety at Work. As yet, in six European countries skin cancer by occupational solar exposure is a recognized occupational disease, yet markedly underreported.

CONCLUSIONS:

UV-dosimetry has shown up to 500% additional annual UV-radiation in construction workers compared to the average population; and, at the same time, has highlighted the necessity for improved prevention. This may be by pro-active workplace design and work place organization but also by suitable UV-protective clothing and regular use of sunscreens. Like in the prevention of contact eczema, lack of knowledge and inconvenience of UV-protection seem the dominant factors, explaining for negligence and for carelessness. Therefore, interdisciplinary workers' education is required. Also, screening schemes and preventive treatment has to be facilitated. The problem of occupational NMSC will be increasing with demographic change, higher life expectancy and longer working life. At the same time, specific work protection laws with set exposure limits have to include solar UV-radiation, not only, as presently on the EU level, UV-radiation from artificial sources. Currently, in Europe, the "healthy skin@work" campaign raises public awareness to the problem. Furthermore, a recent EU H2020 COST Action "Development and Implementation of European Standards on Prevention of Occupational Skin Diseases (StanDerm)" comprising experts from 29 countries will help to further enhance scientific knowledge for evidence based, targeted prevention to improve rural health, even in this respect.

Skin barrier protection

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Background

Skin is a highly specialized and efficient barrier preventing excessive loss of water from the body and penetration of exogenous substances and UV radiation into the body. Gradual damage of the skin barrier e.g. due to repetitive exposure to skin irritants in the work place might lead to development of irritant contact dermatitis. Next, a damaged skin barrier will facilitate ingress of contact allergens and microorganisms and increase UV absorption in outdoor workers. Skin protection aiming at reducing exposure and repair of the skin barrier is therefore essential for the prevention of occupational skin diseases (OCD) including UV-related skin cancer.

Methods

This presentation will summarize current research on efficacy of various products aiming at skin barrier protection and repair including sunscreen formulations.

Results

Various topical formulations have recently been designed to provide skin barrier protection or to accelerate skin barrier repair. Working mechanisms of used products are mainly based on delivery of specific lipids and hygroscopic substances, and agents that regulate pH of the skin or occlude the skin. There is some evidence to support that regular application of barrier repair and barrier protection products may be of benefit in the prevention of occupational contact dermatitis.

Discussion

Maintenance and repair of the skin barrier should represent a major component in the prevention programs in occupations associated with high risk to OCD. However, further efforts are needed to develop best practices for their use in various occupational settings and increase adherence to skin protection measures.

Occupational exposure of workers with GENESIS-UV: dosimetric results in Germany

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Ultraviolet radiation (UVR) is cancerogenic. Since most of the solar UVR is absorbed in the ozone layer of the atmosphere, only a fraction of UV-B and UV-A reach the surface of the earth. Nevertheless, this amount of UVR may damage the skin and cause skin cancer. The relationship between UVR and non-melanoma skin cancer has been proven scientifically.

Up to now, there is only poor knowledge of the *de facto* irradiance, the “amount (dose)” of radiation, during different occupational activities. To obtain reliable data, measurements at a distinct time are not suitable, but rather long-term data acquisition with dosimeters are necessary, making measurements very challenging.

GENESIS-UV (GENeration and Extraction System for Individual expoSure) has been designed to conduct measurements of occupational exposure against UVR. In the current study, 300 workers per year throughout Germany are equipped from April to October. With a data rate of 1 per second, UV irradiance is measured, along with accelerometer and magnetometer data. Such a dataset enables us to document the individual movement of the dosimeter with respect to the sun, and also to connect our data to global irradiance data and weather data. Such a detailed picture of the UVR exposure has not been presented so far.

First data will be shown emerging from the measurements in Germany 2014 and 2015.

Migration and Health

Self-reported heat illness among migrant Hispanic farmworkers in North Carolina

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OBJECTIVES: Heat stress is a major occupational hazard faced by farmworkers. A heat index of above 90°F (32°C) during the growing season is common in the southern US. This analysis examines the heat stress experiences of 101 Hispanic migrant farmworkers in North Carolina.

METHODS: In 2013, an interviewer-administered questionnaire was conducted that asked migrant farmworkers about heat stress experiences over the previous 3 months (June, July, and August), including outside and inside work, and in housing. Symptoms of heat stress recorded included: sudden muscle cramps; nausea or vomiting; hot, dry skin; confusion; and dizziness. Questions were asked about any precautions taken to prevent heat stress. Personal characteristics and recent work conditions were measured. Heat illness was defined as having any heat stress symptom.

RESULTS: All participants were Mexican men over the age of 30. Only 9% had more than a high school education. Sixty-nine percent reported working outside (n = 68) and inside (n = 18) in extreme heat. A quarter of the sample reported spending time in extremely hot housing (n = 27). Of those who worked in extreme heat, 39 (55.7%) experienced heat illness. The vast majority reported working in tobacco in the following tasks: planting (21.8%), harvesting (66.3%), topping (23.8%), and barning or loading (64.4%). Working in harvesting and topping tobacco were associated with heat illness, as was working in wet shoes or clothing. Extremely hot housing was also associated with heat illness. Drinking more water and taking breaks in the shade were the two leading precautions taken, while changing hours and activities were the least reported precautions.

CONCLUSIONS: Over one-third of the workers experienced heat illness during the first 3 months of the agricultural season demonstrating that this population is at risk of occupational heat stress. Policies that empower farmworkers to guard themselves against heat stress must be considered. Model policies have been implemented and evaluated in California, but those have not been adopted in other regions of the US.

Employment policies related to immigrant workers in the dairy industry: A comparative policy analysis across 10 countries

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Objectives:

Recent publications identify two trends currently affecting the dairy industry in multiple countries around the world: first, the size of dairy production is growing rapidly; secondly, increasingly the workers in this very labor intensive setting are emigrating from countries other than the worksite location. The policies impacting these workers, vary from country to country and set the stage for the following objectives:

1. Provide a perspective of the current trends in the dairy industry and associated immigration policies around the world
2. Utilizing a social justice policy framework compare 10 countries employing an immigrant labor force in the dairy industry on multiple constructs.

Methods:

The purpose of a policy analysis is to examine the consequences of laws and procedures, intended and unintended on a target population. Utilizing a social justice policy analysis framework (Jimenez, 2010; Reich, 2015) the impact of policies in diverse countries affecting the immigrant workforce are presented and compared. Key constructs utilized include:

1. Discussion of the intended and unintended effects of the immigration policies
2. Presentation of the various types of benefits offered by the policies?
3. Analysis of horizontal equity across countries

Results:

Policies analyzed among selected countries indicate substantial variation in wages, length of stay, employer responsibilities, country entrance procedures and additional benefits provided. A common baseline among countries accepting immigrant workforces should include a recognition of minimum wage, and basic human needs such as access to healthcare, housing, on-the-job training and safe working conditions (Schenker, 2015).

Conclusions:

The demand for agricultural labor including dairy will increase based on trends previously identified. The goal of horizontal equity among countries is dependent upon an immigrant labor force for their dairy production includes not only the need to improve immigration policies, but also recognition of the need for additional tangible benefits for the target population.

A Longitudinal Analysis of Mexican-Born Farmworkers' Depressive Symptoms across Two Growing Seasons in North Carolina

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OBJECTIVES: The objectives for this analysis are to document the trajectory of Mexican-born Latino farmworker depressive symptoms across two agricultural seasons, and evaluate the association between structural and situational stressors on farmworker depressive symptoms.

METHODS: Data for the longitudinal analysis are from seven sets of fixed-response interviews administered to Latino farmworkers during the 2012 and 2013 growing seasons in North Carolina, which is located in the southeastern US.¹ Each interview completed by the 235 farmworkers included the 10-item Center for Epidemiologic Studies Depression (CES-D) scale that measures depressive symptoms during the previous week, the potential value ranging from 0 to 30, higher numbers indicating greater depressive symptoms.²⁻⁵ Structural stressors, those likely to remain consistent across growing seasons, initial age, education, English fluency, marital status, and visa status, were collected during the baseline interview. Data about situational stressors, those that are likely to vary over time, such as experiencing discrimination in the US and having difficulty finding someone to talk to about feelings, were collected during each of the seven interviews.^{2,6,7} Time variable items were selected for inclusion based on multiple criteria: not highly correlated with structural stressors, potentially relevant to all participants, and expected to change substantially during the growing season. Time was treated as an ordinal value. Data were analyzed using a mixed effects model.

RESULTS: The mean depressive symptom scores ranged between 4.24 and 5.35 across the 7 time points. Changes in the mean depressive scores across growing two seasons were statistically significant. The CES-D scores decreased across the first growing season. During the second growing season, the CES-D values decreased from the initial 2013 value and then increased. Greater formal education was associated with lower CES-D values. Experiencing stress due to discrimination, and having difficulty speaking about feelings were associated with increased depressive symptoms.

CONCLUSIONS: Both situational and structural stressors are associated with depressive symptoms among Mexican-born Latino farmworkers. Depressive symptoms decrease during the growing season, and can increase near season's end. Mexican-born farmworkers face substantial structural and situational challenges that affect their well-being.

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Living conditions, work and health of Mexican migrant farm workers

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BACKGROUND:

According to the latest available data, in the country there are 2, 040, 414 agricultural workers, from which approximately 430,000 are migrant laborers, who sell their work in exchange of low salaries and precarious working conditions. They belong to the poorest and marginalized sector of agricultural workers

OBJECTIVE:

To describe the characteristics of living, work and health-disease conditions of Mexican migrant farm workers

METHODS:

In the first part it is described the characteristics of living, working, and health-disease conditions of agricultural migrant laborers in Sinaloa Mexico. For this part a bibliographic review was made. In the second part a brief report of a research with 463 migrant laborers of an agricultural company in the same state of the republic is explained.

RESULTS:

Hiring laborers to agricultural fields is done in two ways, when workers go directly to fields or through intermediaries called "camioneteros" (truckers) or working recruiters. This population comprises a significant proportion of women and children, who are incorporated to immigration processes and waged labor. A large part of the workers and their families live in housing provided by the agricultural companies. Both crowded conditions and building materials influence the possibility of acquiring infectious diseases. Most workers don't have social security or medical service. The working methods are per day, per job, or by contract. The basic unit of work organization is the squad, which is made up of 30 or 35 workers, mostly migrants. In general, the laborers migrate in groups to the poles of agricultural development; in this case, 73% traveled with their families. 35% are illiterate. 56.1% of the studied population referred having from 1 to 3 symptoms related with pesticides, 18% between 4 and 6, 11% between 7 and 9, 8% between 10 and 12, and 6% 13 or more. 55% of women and 51% of children less than 14 years old had Anemia.

CONCLUSIONS:

It is essential the study and diffusion of health-disease, living, and working conditions of the agricultural migrant laborers to collaborate in the making of proposals that contribute to a better quality of life of these workers.

Migrant Workers in Swedish Agriculture – a Challenge and a Solution for Farmers and Growers

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OBJECTIVES:

Migrant workers in agriculture are a rather new but growing trend in Sweden, due to lack of local workers and economic benefits for employers. The project started with a review of the literature, followed by a web-based survey to agricultural employers. The survey was responded by almost 4000 employers, indicating that 20% of them used migrant workers during 2011. Results showed that migrant workers are common both for shorter and longer periods within animal production, horticulture, forestry as well as construction work. Most of the migrant workers come from the Eastern part of Europe, such as Poland, Lithuania and Romania, with the goal to earn a better income. The main focus of the project is the focus on communication issues; such as working instructions, health and safety issues and food hygiene.

METHODS:

Data was collected through interviews on 15 workplaces with the employers, native Swedish co-workers and the migrant workers in their own language or by an interpreter.

RESULTS / CONCLUSIONS:

The results shows a number of critical problems which has led to miss-understandings, increased health and safety risks as well as food hygiene incidents. Positive solutions and good ideas have also been detected. The results of the project has been presented at a work-shop with the stakeholders in order to make an action plan for further actions including research, international collaboration and education. A guide-book for employers is one of the practical results. We are now looking for international collaboration since we believe this is an area of research that would benefit very much of collaboration in projects within EU and with or without other partners.

Keynote lectures - 11th September 2015

Access to Health Care – Greatest Challenge for Rural and Remote Health

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OBJECTIVES: To analyse how the access of Health Care in Rural Areas affect the health parameters in Rural Areas.

METHODS: The author has compared the different interventions carried out in 235 villages in India.

WHO World Health Assembly adopted the HEALTH FOR ALL in 1981 which defined that health is to be brought within reach of everyone in a given country. Health For All implies the removal of the obstacles of health – that is to say, the elimination of malnutrition, ignorance, contaminated drinking water and unhygienic housing – quite as much as it does the solution of purely medical problems such as lack of doctors, hospital beds, drugs and vaccines.

Health for All depends on continued progress in Medical Care and Public Health. The Health Services must be accessible to all through Primary Health Care, in which basic medical help is available in every village, backed up by referral services for more specialised care.

The author takes a Macroscopic view of the Health For All Goal in some countries and discusses the relationship between the Access and Health For All.

The author has been working areas of India and his successful experience with the multifaceted approach towards reduction of morbidity and mortality will be elaborated and shared. This approach could be used as a model for sustainable health and development in developing countries.

A Swedish strategy for safety and health in agriculture – from zero vision of fatalities to certification of working conditions

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OBJECTIVES:

In Sweden there has been a number of initiatives in order to improve the working conditions and reach the goal - Zero fatalities in agriculture. The main initiative was the five year national project "Safe Farmers Common Sense" (Säkert Bondförnuft), funded by the European Commission (EU) during 2009-2013. Evaluations of the results are on its way, but the year 2013 was historic with zero (0) work-related fatalities in Swedish agriculture. Since then there have been fatalities again and the project was not given further funding. The project is now being evaluated in a number of studies including follow-up interviews and enquiries among farmers and extension personnel, injury statistics and interviews with injured farmers, farm workers and family members.

In order to break new grounds we are now initiating two new initiatives in order to integrate health and safety into the modern professional farming: Integrating health & safety into business management in agriculture and establishing national standards for working conditions in agriculture.

METHODS:

Standards for Working Conditions

Developing Swedish certification standards for work in agriculture. An interesting process will lead to a standard and possibilities to be certified as a work place with healthy and safe working conditions. The work is coordinated by Sigill Kvalitetssystem and involves a working group with representatives from the whole food-chain as well as health & safety experts. The first goal is to include companies with field grown crops and employs seasonal farm workers, mainly migrant workers.

Health & safety into business management in agriculture.

The Swedish Centre for Agricultural Business Management at the Swedish University of Agricultural Sciences in Alnarp. The interesting approach is that the Centre will have a large integrated proportion of work science and work environment management in research, education as well as in extension. The goal is that health & safety should be a natural and obvious part of modern farm management.

CONCLUSIONS:

After a five year national project "Safe Farmers Common Sense" are we now taking further steps towards our goal – Zero fatalities in agriculture – by new initiatives in order to integrate health & safety in professional management and by implementing Swedish standards for working conditions in agriculture in order to improve the working conditions for migrant farm workers. Both initiatives will be evaluated.

GPs and Occupational Health: the How to Achieve the dual goal of access and quality in rural health care

Pekez-Pavlisko T.

EURIPA Interim President, WONCA Working Party on Rural Practice – Co-chair

European countries differ in their healthcare organization. Organization of agricultural occupational health differs similarly. On one hand it is very easy to find quality literature from areas such as Great Britain, Ireland or Scandinavian countries, on the other it is difficult to find such literature regarding Southeastern Europe. Most of the population working in agriculture live in areas of low population density where it is difficult to access certain segments of healthcare. While Western Europe has a large number of farms spread across large areas, in Southeastern Europe farms are mostly small in size. In light of these facts, a research on healthcare availability for population in rural areas should be conducted, as well as accessibility to occupational physicians for farm workers. It is safe to assume that availability of occupational physicians varies, and is particularly smaller in Southeastern Europe. Considering that general practitioners maintain close relations with the population of rural areas, it is necessary to consider introducing special education in occupational health for agricultural workers. At the same time it is important to conduct activities in increasing decision makers' consciousness on farmers' occupational health. Special attention should be given to heads of insurance companies which would adequately pay for general practitioner's work in the area of agricultural occupational health.

One of the good examples is the miniproject in Kutina where a systematic examination of owner of small farms (BMI, blood pressure, glucometry, spirometry and ECG) was performed on 20 farmers, as well as counselling on proper usage of pesticides and herbicides, injury prevention and sunlight radiation.

Impact of Globalisation on Rural Workers' Working Conditions and Occupational Health

Rantanen J.

Professor Jorma Rantanen, MD, PhD

Director General Emeritus

Finnish Institute of Occupational Health, FIOH

Globalisation has both beneficial and adverse effects on rural work, but its occupational health impact has called less attention. Here only a few key issues are mentioned and further analysed in the presentation.

- Employment impact: Rapid growth of non-farming jobs (associated with mass urbanization) and marginalization of family farmers and rural workers. On average, an impressive reduction of poverty (by 50% since the 1990s)
- Massive unemployment among the low-skill and poor rural workers. Growing gap between poorest and middle-income groups.
- Imbalanced competitiveness situation of family farming in the globalizing market
- Occupancy of food producing land for non-food agricultural production and changes in land ownership
- Growing risks, hazards and work load by climate change associated with natural disasters, drought and erosion of land by floods
- Occupational safety risks related to climate change such as heat stress, UV cancer, emergencies and new biohazards.

There are, however, some positive signals which could be further amplified:

- Growing attention by International Organizations to rural workers' situation
- ILO Domestic Work Convention and ILO informal sector programmes. ILO's and others' attention to safety and health of workers throughout the whole supply chain
- G20 Melbourne Declaration on better safety and health for all
- WHO Global Strategy on Occupational Health for All and the Global Action Plan on Workers' Health.
- Expansion of UN MDGs from 8 to 17, including elimination of poverty and hunger and combating climate change, land erosion and promoting sustainable development.

Poster Presentation

Health of the rural population

Work Organisation and Occupational Health and Safety in Australian and United Kingdom Horticulture

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OBJECTIVES:

This study describes how work organisation, particularly itinerant and temporary employment, is having detrimental effects on the occupational health and safety (OHS) of workers, many of whom are foreign-born temporaries, in two countries: Australia and the United Kingdom (UK).

METHODS:

Data are drawn from 67 semi-structured interviews with horticultural fieldworkers, employers, labour providers, and industry, union and government representatives. The temporary labour migration mechanisms affecting the horticultural workforces were compared and real or perceived impacts on worker vulnerability and OHS outcomes were examined. The research design allowed the reporting of perceived pesticide exposure and potential sources of exposure.

RESULTS:

The itinerant nature of the work appeared to contribute to hazardous forms of work disorganisation arising from constant changes to co-workers and experience from job-to-job, and networks of temporary employment obstructed the quality of information flow on pesticide use and preventative behaviours. The critical factor seemed to be that the work was temporary and itinerant; workers were less concerned about employment conditions attached to a specific employer and did not appear to consider long term health but rather immediate safety issues, and their dependency in subcontracting chains and the absence of effective union representation or ability to interact with local workers were factors. Workers' status as foreign-born exacerbated this vulnerability i.e. economic pressures to earn and in the case of backpackers the need to secure 88 days of harvesting work to get an extension visa. While language skills and education have been seen as making foreign workers more susceptible to exploitation, this study found no significant differences.

CONCLUSIONS:

This research focussed on work organisation rather than ethnicity and the findings tend to suggest that it is not just the vulnerability of foreign-workers, which exacerbated problems but is also a part of the way work is being organised. The precariousness arising from work organisation seemed to be the most fundamental problem.

Active search of occupational and work-related diseases using administrative databases: a pilot project on musculoskeletal disorders

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Objectives

Occupational and work-related musculoskeletal disorders are nowadays the most frequent reported diseases in Italy, with an increasing rate of 600% in 2007-2011 period, but their incidence is still underestimated.

The aim of this study, conducted as part of the strand already used by the OCCAM project (1), is to quantify the possible underestimation of these diagnosis by collecting and processing clinical and demographic data from the information available in administrative databases.

Methods

We collected the Hospital Discharge Reports (HDR) of the patients living in Lodi area, regarding the period 2008-2010 and sent from all over Italy to Lodi Local Health Unit (ASL). Among them we selected those with the following ICD 9 codes: 726.10 - disorders of bursae and tendons in shoulder region, unspecified; 726.19 - other specified disorders of bursae and tendons in shoulder region; 726.32 - lateral epicondylitis; 722.52 - degeneration of lumbar or lumbosacral intervertebral disc; 722.73 - intervertebral disc disorder with myelopathy, lumbar region; 354.0 - carpal tunnel syndrome; 354.1 - other lesion of median nerve; 354.2 - lesion of ulnar nerve.

Cross-checking data from HDR and data included in Italian Social Security Service (INPS) archive, useful to define the different employers' activities, we identified those cases of musculoskeletal pathologies most likely work-related (2).

Subsequently we reviewed all the clinical records of identified cases and, when necessary, we interviewed the patients. In some cases also the Occupational Physicians of the companies have been involved.

Those cases we recognized having an occupational etiology have been reported to the Authorities as provided for by Italian Legislation.

Results

Among the 350 initial workers with musculoskeletal disease likely to be associated with working conditions, 74 cases concluded the diagnostic process: in 16 cases the study individuated an under-reporting of occupational musculoskeletal disease.

Conclusions

All diagnosed cases of occupational disease, except two, had not been previously recognized. This result confirms that today musculoskeletal work-related diseases are underestimated and that analogous focused studies are required in order to detect them.

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Is rural a safe place to live and work?

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OBJECTIVES: to investigate possible contributing and risk factors causing an increase in the incidence of malignancies in a rural community in North-West Romania.

To determine the most effective community based interventions targeting risk reduction in rural population.

METHODS:The target population is formed of the 1200 adult active population registered with a GP surgery in a rural setting,situated 25 km from the nearest secondary care provider.

The majority of the adults in the village does agricultural work full time or part time.

We determined the incidence of cancer in the past ten years in the target population as well as geographical distribution of the cases in the area.

We analysed the existing environmental, occupational hazards in our area as well as the frequency of Gp visits/ person in the target population for curative and preventive reasons.

RESULTS: We found that exposure to different environmental hazards of the working age rural population is not addressed properly due to lack of information, negligence, inefficiency of prevention and health education programmes.The rural workers have reduced access to regular occupational health checks and their addressability to health services is also reduced.

CONCLUSIONS: Cancer incidence and mortality rates in rural population are increasing due to the effect of socio-economic deprivation, environmental hazards,lack of prevention and targeted health education programmes including occupational health services.

Educational activities addressing both patient's and primary health care provider's needs can play an important role in prevention and early diagnosis of cancer and other non-communicable diseases.

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A preliminary survey involving the elderly living alone in a mountainous area for the difficulty of shopping, their economic situations, diet, and nutritional intake

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OBJECTIVES: A preliminary survey involving a limited number of elderly people was conducted to examine the relationship of obtaining food with diet and nutritional intake.

METHODS: The subjects were 20 single females aged 65 years or older living in Mine City, Yamaguchi Pref. Between September and October 2012, a questionnaire survey was conducted to ask them about the means of obtaining food and their economic situations. A two-day survey based on diet recording was also conducted to calculate and assess their food and nutritional intake. The subjects were divided into groups according to the status of their nutritional intake, and statistical analyses were conducted to examine independence in daily life, obtaining food, and their relationships in association with their economic situations. The χ^2 test was adopted as a nominal scale, and Welch's t-test was used to assess quantitative data.

RESULTS: The energy intake was 1,802kcal/day and its percentage of the standard level provided in the dietary reference intakes (DRI) was 102.9%, which suggests that the energy intake was desirable in general. All subjects in the group of the elderly whose energy intake was sufficient (n=12) required no support in their daily lives ($\chi^2=5.29$, $p=0.070$). Specifically, the energy intake in the group of elderly females without difficulty shopping (n=15) was favorable, whereas that in the group with difficulty shopping (n=5) was significantly lower ($p<0.05$). The energy intake in the financially secure group (n=11) was favorable, whereas that in the financial difficulty group (n=5) was significantly lower ($p<0.05$).

CONCLUSIONS: The subjects of the survey included the elderly who may have difficulty shopping in the near future. Since elderly people who are unable to go shopping often develop malnutrition - a symptom of geriatric syndrome, they may become bedridden or require nursing care, which is expected to influence their life expectancy.

Effects of oral exercise on oral function and oral health related quality of life of the elderly

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OBJECTIVES: The purpose of this study is to examine the effects of oral exercise on oral function and denture satisfaction for the elderly using dentures.

METHODS: The study was performed with targets of the elderly in 13 senior community centers in Cheongsong-gun, Gyeongsangbuk-do, Korea from September 2013 to April 2014 and the study subjects were divided into two groups such as an intervention group provided with 8 week oral exercise program and control group. Data on oral function, denture satisfaction, and oral health related quality of life (OHIP-14) were analyzed between 79 subjects from intervention group and 72 subjects from control group.

RESULTS: For oral function, salivary flow rate, mouth opening, pronunciation and salty taste were significantly increased in the intervention group ($p < 0.01$). There were significant differences in changes in salivary flow rate, mouth opening, pronunciation and salty taste between two groups ($p < 0.01$). For denture satisfaction, there were significant differences in changes in masticatory function satisfaction, fixing function satisfaction, general treatment satisfaction and denture satisfaction between two groups ($p < 0.05$). There were also significant differences in amount of change in oral health related quality of life between two groups ($p < 0.05$).

CONCLUSIONS: In conclusion, oral exercise was effective on improving oral functions and denture satisfaction of the elderly using dentures. In the future, it will be necessary that an oral exercise program can be utilized to improve oral health of the elderly using dentures.

Self- and familial awareness of hepatitis status among hepatitis B and hepatitis C carriers in Korean rural areas

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OBJECTIVE: Hepatitis is the most important cause of hepatocellular carcinoma in Korea. This study aims to estimate the self- and familial awareness of hepatitis status among the hepatitis B and C carriers and their cohabitant family members in Korean rural areas.

METHODS: Total of 5,017 randomly selected residents in rural areas were participated on the seroepidemiologic and questionnaire survey. We found 326 hepatitis B surface antigen (HBsAg) carriers or hepatitis C antibody (HCVAb) carriers and their 306 cohabiting family members. Subjects were considered unaware of hepatitis status if they answered that they had no history of hepatitis or no familial members diagnosed with hepatitis. We also explored the factors associated with the self- and familial awareness of hepatitis status.

RESULTS: Among the 208 hepatitis B carriers and their family members, 48.1% and 20.7% were aware of their own or cohabitant's hepatitis status, respectively. Only 31.4% of HCV carriers and 9.1% of their cohabiting family members were aware of their own and cohabitant's hepatitis status. The group of younger age (<65 years), with higher education or income level, and salaried employee were more likely to aware their own hepatitis status. However, no demographic factors were related to awareness of familial hepatitis status. In a multivariate analysis that include various demographic factors and health-related factors, younger age (OR 1.76, 95% confidence interval 1.03-3.03) and higher education level (p-for trend 0.008) were significantly associated with the self-reported awareness of hepatitis status.

CONCLUSIONS: Self- and familial awareness of hepatitis status in Korean rural areas were lower than the awareness in urban area which previously reported. Differences according to demographic and socioeconomic factors within the subjects were also found.

Is it possible to eliminate MERS? – From the experience of brucellosis control in South Korea

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OBJECTIVES: MERS is maybe known as one of zoonoses from camel to human. In this study, we would discuss about the possibilities of the elimination of MERS through the experience of brucellosis control in South Korea.

METHODS: Through literature review, we considered the activities for control of brucellosis and MERS both human and animals in both countries. And also we reviewed the similarities from cultural aspects in two regions, to be easily infected by close contact with animals.

RESULTS: In South Korea, Korea Centers for Disease Prevention and Control (KCDC) performed the survey annually on targeted high risk group for brucellosis such as livestock farmers since 2005. By these surveys during 10 years, seroprevalence of brucellosis among high risk groups has been reduced to zero steadily. With these activities, in the animal sector, premarketing test and annual test were implemented for all cattle of older than 1 year since respectively 2004, 2007. Through these efforts, both bovine and human brucellosis has been decreased since 2006. Unfortunately now these control activities for camel are supposed not to be sufficient in Middle East region. In aspects of culture, both cow and camel are similarly very close to human, providing labor and food. For this reason, when these animals are infected, human is easily exposed to diseases, and both animals may not be easily culled. And also Korean usually enjoy eating raw beef (*Yukhoe*), and similarly Middle Eastern enjoy drinking raw camel milk.

CONCLUSIONS: The successful control of brucellosis in South Korea was achieved from cooperation by the veterinary as well as medical sector. For also control of MERS, more extensive activities in Middle East region must be implemented. Particularly, avoidance of eating unpasteurized dairy products, and culling of infected camels with surveillance and compensation policy will help to eliminate MERS.

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The Effect of Health Education Program on Dyslipidemia of Male Workers

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Objectives: This study aimed to clarify the impact of health education and a consultation program on male workers with dyslipidemia.

Methods: This study was performed, from Aug. 2012 through Mar. 2013, for male workers in their 30-50s whose LDL levels were 160mg/dl or more for the last five years, four companies with 700 employees meters located at Gyeongsangbuk-do, Republic of Korea. Among workers who agreed to participate in the study, 35 participants were randomly allocated to the intervention group and control, respectively. Excluding 18 participants (8 in the intervention group and 10 in control) who dropped out during the study period, a total of 52 workers (27 in the intervention group and 25 in control) were selected for the final analysis.

Results: Values of the plasma lipid level showed a significant decrease in comparisons before and after the intervention and between the period after the intervention and the 5-month follow-up, values measured in the follow-up showed a significant increase compared to those obtained in the period after the intervention.

Repeated measure ANOVA revealed a significant difference in total cholesterol ($p<0.05$) and low density cholesterol ($p<0.01$) between the intervention group and control. Analyzing the interaction between the factors, there was also a significant difference in high density cholesterol and triglyceride.

Conclusions: Continuous and systematic health education and consultation in every 3-6 months are required. Moreover, it is necessary to develop human resources and services required to maintain and manage modified behaviors and clinical outcomes.

The Effects of School-based Fissure Sealant Program for Preventing Dental Decay in the Permanent Teeth of Schoolchildren in Rural and Urban Areas

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Objectives: The aim of this study was to evaluate the effects of fissure sealants on the occlusal fissures of permanent first molar for three years in schoolchildren.

Methods: In 2005-2008, 4,768 students from 34 elementary schools located in Gimcheon rural and city areas were targeted.

Results: As for the DMFT rate depending on whether placing the fissure sealants, the teeth with the fissure sealants showed 1.4% in 1 year follow-up, 2.7% in 2 year follow-up and 4.1% in 3 year follow-up. When it comes to the teeth without the fissure sealants, it was 34.0% in 1 year follow-up, 47.4% in 2 year follow-up and 56.5% in 3 year follow-up, which showed that DMFT rate of the teeth with the fissure sealants was very low.

According to the comparison results of DMFT rate depending on the tooth brushing frequency and whether placing the sealants, DMFT rate between 'with the sealants' and 'without the sealants' were 7.8% and 71.5% each in 3 years when it comes to students who brushing once a day, and DMFT rate between 'with the fissure sealants' and 'without the fissure sealants' were 4.0% and 57.3% each in 3 years as for the students who brushing twice a day, and DMFT rate between 'with fissure the sealants' and 'without the fissure sealants' were 3.8% and 41.0% each in 3 years as for the students who brushing three times a day.

Conclusions: These results indicated that the fissure sealants excelled at preventing the dental caries, but if the brushing was not properly carried out, the effects wore off enough to offsetting the effectiveness of the fissure sealants.

Trend in colorectal cancer incidence in Chungnam province, South Korea (2000-2011)

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OBJECTIVES:

Colorectal cancer is the third most common cancer in South Korea. We explored the time trend in colorectal cancer incidence in Chungnam province, a rural region in South Korea.

METHODS:

Using the database from the Chungnam Cancer Registry (CCR), age-standardized (to world standard population) rate for incidence (ASRW) was calculated. Average annual percent change (AAPC) was assessed as a trend indicator.

RESULTS:

Incidence of colorectal cancer showed increasing trend in both sexes. Over the years 2000-2011, ASRW was increased from 29.8 to 52.0 (AAPC, 5.5%) per 100,000 person-years among men and from 15.9 to 25.0 (AAPC, 4.2%) among women, respectively. The increasing trend was more rapid for colon cancer (AAPC, 7.3% in male, 5.3% in female) than rectal cancer (AAPC, 3.9% in male, 1.2% in female).

CONCLUSIONS:

As a result of the rapid increase in colorectal cancer incidence in the last decade, Chungnam province may be one of high risk areas in the world. Monitoring and intervention are required on the risk factors which may contribute to the trend.

Experience with radionuclide therapy for malignant tumors at a rural community hospital

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OBJECTIVES: Our hospital is located in a provincial city in Japan, where we provide external radiotherapy using a linear accelerator and radionuclide therapy using radioactive isotopes for malignant tumors. This study summarizes our experience with 3 types of radionuclide therapy, along with their problems and future directions for our department.

METHODS: Remnant ablation after resection of thyroid cancer using iodine-131 (I-131), pain-relieving treatment of solid carcinoma with bone metastasis using strontium-89 (Sr-89), and radioimmunotherapy for chemotherapy-refractory malignant lymphoma using yttrium-90 (Y-90) were performed. The radiation dose in the exit criteria was determined by the Japanese government.

RESULTS: Remnant ablation of thyroid cancer with I-131 was used in 16 cases (2 cases treated twice). Pain-relieving treatment with Sr-89 was used in 57 cases (7 cases treated more than once). Radioimmunotherapy using Y-90 was used in 36 cases. Effectiveness of I-131 radionuclide therapy in the remnant thyroid tissue was demonstrated by radionuclide image in 9 cases. Pain-relieving treatment in the numerical rating scale (NRS) evaluation yielded pain relief in 29 cases. Therapeutic effects of radioimmunotherapy using yttrium-90 (Y-90) were CR (n=14), PR (n=10), SD (n=4), and PD (n=4).

CONCLUSIONS: Three types of radionuclide therapy for malignant tumor treatment were judged effective, but additional experience with more cases will be obtained for each therapy. In future, we will use a new method of radionuclide therapy, for example, for cases of pheochromocytoma and neuroblastoma.

Eliminating asbestos-related diseases in Albania

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OBJECTIVES:

To examine the problem of asbestos in Albania and to recommend a research plan of action.

The World Health Organization estimates that 107,000 global annual deaths are caused by mesothelioma, asbestos-related lung cancer and asbestosis. In 2005, occupational exposure to asbestos was estimated to cause 43,000 mesothelioma deaths and among those 7000 were attributed to Europe. With a population of approximately 3 million, Albania is a middle income country (MIC) with half of the population living outside urban areas. Like other MICs in Europe, Albania has been afflicted by an accumulation of asbestos contamination combined with weak regulatory controls. To the extent that systematic data are available, the amount of asbestos used in Albania between 1930-1990 is estimated to be 188,000 tons. This is likely an underestimate and more complete data are lacking. The most ubiquitous asbestos containing product in Albania is asbestos-cement, containing 10-25% asbestos. A factory producing asbestos-cement was built in the 1960s and operated until 1992. The material may be compressed into flat or undulated sheets to build roofs or walls, and can produce a range of other products such as pipes, drains, guttering, conduits, and tanks. Risk groups particularly vulnerable to asbestos health threats include workers exposed to asbestos during construction or operation, as well as local residents who may be exposed to the release of asbestos fibers.

METHODS:

This poster will describe a public health research project designed to ultimately phase out asbestos products from circulation in Albania through multidisciplinary and multi-level interventions. The objectives of the project are: 1. Raising awareness of asbestos hazards among the public and policy-makers; 2. Capacity building in the health professionals and labour inspectorate; 3. Legislation of a national program for eliminating asbestos-related diseases. A map that provides a territorial analysis showing areas where asbestos is still present in various forms will be presented to highlight to show where more cancer preventive interventions through information and screening are needed and to highlight locations where recovery and remediation should be targeted.

CONCLUSIONS:

Asbestos in Albania is an environmental public health and rural health problem needing public health research and policy attention.

Cancer risk in rural areas

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Hospital respiratori disease –Oteshevo R Makedonia

OBJECTIVES: The malignant diseases marks trend of pore at the overall population. At the rural areas(which falls my orchard region-Prespa) which are used preparations for plants protection in latest years, it is visibly increased the number of diseased.It remains the question – how to deal with risk factors (air polution, pesticides,smoking), in order to preserve health population.

METHODS: Of the medical Journal is taken data for 96 people which are called in review. All are in history in repetitive respiratory symptoms and their treatment. At all respondents were made battery investigations (spirometry,oximetry.ECG and RTG pulmonary).it was elaborately taken personal and famiy history.

RESULTS: Of investigated group– 53(50,96%) patients are in direct contact with hemical preparations, 43(49%) are passive consumers(indirect contact).All are smokers and are exposed at general air pollution. At 39 is confirmed with RTG at lungs and MS at lungs.17 are with recurrent broncho obstructive epizods.

Polymyalgia Rheumatica (PMR): Clinical, laboratory, and immunofluorescence findings in the elderly in Japan

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Background:

Polymyalgia rheumatica (PMR) is characterized by symptoms of muscle pain and stiffness, aching, and tenderness of the neck, shoulders, and pelvic girdle with fever, general fatigue, body weight loss, appetite loss, and sometimes anemia. It mainly affects individuals over the age of fifty years, and the etiology and pathogenesis have remained uncertain. We selected 13 patients with PMR, for whom we had performed detailed immunologic, histologic, and immunofluorescence studies.

Methods:

We retrospectively selected 13 patients with PMR. They fulfilled the following clinical and laboratory conditions: age older than 50 years; suffering from severe myalgia and stiffness of proximal muscles without muscular weakness or atrophy for at least one month; a markedly increased erythrocyte sedimentation rate ($\text{ESR} \geq 50$ mm/hr) and strongly positive C-reactive protein (CRP) level; normal serum creatine kinase (CK) concentration, and usually negative as to rheumatoid factor (RF) and antinuclear factor; and a dramatic response to low doses of steroids.

Results:

The patients ranged from 64- to 100-years-old, and were 9 men and 4 women. All patients had suffered from severe myalgia in at least two parts of the body including the neck, shoulders, and pelvic girdle. The myalgia had persisted for one to 4 months. The ESR and CRP values ranged between 50 and 148 mm/hr, and 4.68 and 32.43 mg/dL, respectively. An immunofluorescence study of muscle biopsy specimens revealed IgG, IgA, and fibrinogen deposits in the perifascicular area of the perimysium.

Conclusions:

The presence of fibrinogen and fibrinogen degradation products (FDP) in the perimysium is probably due to the enhanced vascular permeability resulting from inflammation of the intima. These findings suggest that immune complexes play a role in the pathogenesis of PMR.

Changes in elderly prostatic cancer patients: A single rural community hospital experience

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OBJECTIVES:

Over the last decade, remarkable advancements have been made in treating prostate cancer. However, in Japan, hormone therapy is the main treatment, especially in the elderly. In Europe and the United States, on the other hand, prostate cancer screening through prostate-specific antigen (PSA) screening is not recommended for men over 80 years of age. We analyzed our institution's data from the past 12 years, including patient history, treatment methods, and the prognosis of prostate cancer patients over the age of 80.

METHODS:

A total of 179 cases of prostate cancer in patients aged above 79 years, between 2002 and 2013, were retrospectively evaluated. Mean age was 83 years, and the eldest patient was 96. Four historical groups were compared: Group A: 2002–2004, 40 cases; Group B: 2005–2007, 48 cases; Group C: 2008–2010, 46 cases; Group D: 2011–2013, 45 cases.

RESULTS:

Patients were observed from 1 to 136 months. Fifty-two patients were observed for more than 60 months. Sixty-two (30%) patients changed treatment courses, including androgen turnover; interestingly, no cancer deaths occurred in these cases, with 22 patients receiving follow-up at 5 years or more. Although 14 (7.8%) cancer death cases existed on the whole (A:B:C:D = 4:4:6:0), these occurred in 2011 or later.

In our hospital, the frequency of prostatic carcinoma has been increasing each year. However, in patients aged 80 and over, the rate has not increased in over 10 years. Over 50 patients survived for 5 years or more by undergoing treatment. By treating prostate cancer in elderly patients, with the use of hormone therapy when appropriate, we can prevent fatalities from prostate cancer.

CONCLUSIONS:

Our results suggest that treating prostate cancer in elderly patients is indeed worthwhile. Further investigation and large-scale analysis in other Japanese hospitals is needed.

Regional Variation of Chronic Periodontal Care Services in South Korea

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Objectives: This study analyzed the 2010 raw data by the Health Insurance Review and Assessment Service. The purpose of this study is to identify variations of dental services for chronic periodontitis patients who are 35 years old or over, among different regions (province), dental care facilities, and their age groups.

Methods: The study analyzed total 278,319 claims made on a main diagnosis of chronic periodontitis, including 264,994 claims made by dental clinics, 8,084 by dental hospitals, 3,509 by general hospitals, and 1,732 by tertiary hospitals.

Results: 1. There was a significant difference in medical care benefit costs between the provinces ($p < 0.0001$). 2. The age groups showed clear difference in the patient co-payment, insurer's costs, and medical care benefit costs paid to dental clinics, dental hospitals, and dental clinic in general hospitals, respectively ($p < 0.0001$). 3. Considering the variations according to first or revisit consultation, the rate of prescription, dental examination, and surgical procedures on chronic periodontal patients by different dental facilities. The radiographic treatment rate for the new chronic periodontal patients at the tertiary hospitals was 2.6 times higher than the dental clinic's.

Conclusions: Further research for variation of dental services need for identify the determinant factors and to minimize the variation and to improve the dental service quality.

Environmental and occupational risk assessment and prevention

From safety to productivity: an ergonomic study on milking activities

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Introduction

Agriculture is a risky activity and all agricultural jobs may affect both the quality of life of agricultural workers as well as the companies' budget in term of occupational injuries and illnesses. Biomechanical risk seems to be nowadays the main factor affecting the burden of disease in the sector. In Italy, for example, the number of reports of musculoskeletal diseases has shown an increase, in period 2010-2013, of 62,26% (1). These data underline an urgent need of prevention. However, doing preventive interventions is not easy because of the high costs, the structural characteristics of agricultural enterprises, and the fact that very often employers claim that the introduction of preventive interventions brings about a reduction of productivity.

Objectives

This study focuses on a particular agricultural activity, which is milking, aims at verifying whether a proper management of milking parlours in terms of health of workers affects productivity.

Methods:

Thirteen dairy farms has been involved in the study. Productivity was assessed with the MVTA Software, addressed at scanning the pace of work. In each milking parlour studied, we evaluated whether the time spent between the beginning of the preparation of the udder and the attack of the milking unit (2) was in compliance with the recommendations of specific sector's guidelines (90 seconds). In addition, the number of workers engaged in the activity has been considered. The evaluation of biomechanical overload was performed on 20 milkers engaged in the same enterprises, through the application of the Strain Index method (3).

Results:

In a milking parlor managed by a single milker, the time spent per animal for the entire milking time was 887 seconds, and 777 in the parlours with more than one milker. When working alone, milkers spent 126 seconds between the beginning of the preparation of the breast and the attachment of the milking unit. The time spent for the same job in the parlours with more than one milkier was 83 seconds. The value of the Strain Index for those who worked alone resulted 17.34, and 12.52 for the others (reference value = 7).

Conclusion:

Our study shows that in the milking parlours managed by only one milker the cows stationed 14% time more than in the companies with more than one milker, with an increase in animal stress which, on its turn, impacts on milk's quality (4). Moreover, when only one milker was engaged, the milking time recommended by specific guidelines was not respected. Moreover, in these companies, the biomechanical risk results 38,5% higher in comparison with the companies with two milkers. Our study suggests that preventive interventions do not affect productivity and promote the quality of the products in this specific sector.

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Industrialized milking parlors operations: analysis of worker's wrist postures

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BACKGROUND:

Work-Related Musculoskeletal Disorders (WMSDs) are one of the most common work-related health problems affecting millions of European workers across many sectors at a cost of billions Euros (1). In particular in Italy there was an increase of 613,4% from 2007 to 2011 in the agriculture sector (2). MSDs in dairy farming are due to the repetitiveness of the operations, loads weight, awkward posture and muscular effort. Among upper limbs wrists represent one of the more susceptible (3). Since the difficulties in collecting quantitative data about awkward postures in the field is often difficult to address problems caused by these disorders and implement solution. Thus, the present study is part of a bigger study conducted by a research group of the University of Milan focusing on the definition of risk profiles of biomechanics overload of upper limb in cow milkers.

AIMS:

The present study aimed to

1. define the milking subtasks with higher risk to cause MSDs of the wrist due to awkward posture through the use of an ergonomic software (Captiv developed by INRS and TEA)
2. Compare the quantitative data (wrist angulation) collected with Captiv Software and Strain Index(SI) data.

METHODS:

Three workers from an herringbone and a rotary milking parlor were recruited. The dominant hand (2 right hand and a left hand) of the workers were equipped by a goniometer during the first hour of milking activity. Each subject was followed by a camera synchronized with Captiv Software. Twenty-two different tasks were individuate and the time spent in Very good, good, fair, bad, very bad postures – as defined by Strain Index Method – has been calculated by Captiv Software. SI score has been evaluate for each worker in the field.

RESULTS & CONCLUSIONS:

The results show that the milking operation were is higher of MSDs are stripping, wiping, and attaching phase. The Captiv results are matching with the results of the SI method for the risk assessment of awkward posture of the wrist in cow milkers.

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Matphyto program in France's overseas departments: crop exposure matrices for retrospective pesticides exposure assessment in the French West Indies and Reunion Island

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OBJECTIVES:

Many agrochemicals products have been used for many decades in agriculture. Recent data from multiple scientific studies showed a positive link between agricultural occupational exposure to pesticides and some chronic diseases. However, few epidemiological studies demonstrate a link between a specific chemical substance and a disease because the retrospective pesticides exposure assessment is complex. To counter this problem, the French Institute for Public Health Surveillance, has set up the Matphyto program which aims at developing crop exposure matrices (CEM) to pesticides. To cover the entire territory of France, we have developed recently CEM for the French West Indies and for Reunion Island.

METHODS:

CEM are databases. They list the use of pesticides for the different French crops, since the 60's. In France, there is no exhaustive database about the use of pesticides in agriculture. To develop CEM we (1) conduct a bibliographic search about the crops and the pesticides used on, (2) combine heterogeneous data collected in order to describe the use over time of pesticides on each crop, (3) characterize different periods and different geographical areas for the use of pesticides, (4) define three indicators of use for each pesticide, crop, period and area:

- Probability (proportion of farms using a pesticide),
- Frequency (average number of annual applications),
- Intensity (average dose to be used for one application).

RESULTS:

On the French overseas, Matphyto firstly focus on two tropical crops: banana in French West Indies and sugarcane in Reunion Island. Vegetable and fruit crops will be taken into account in a second step for each territory. Since 60's, 90 active substances have been used in banana and 60 in sugarcane. Major applications are fungicides in banana (9 in 2014) and herbicides in sugarcane (4 in 2014). Among the 45 chemical families listed, the most used have been: organochlorines, phenoxyacetic herbicides, chlorotriazines, conazole fungicides, paraffinic oil.

CONCLUSIONS:

These CEM are useful tool for epidemiologic studies (i.e. the Coset MSA Cohorte), monitoring survey and occupational medicine, particularly for past exposures. Data will be freely available on Internet. They provide various exposure indicators such as prevalence of occupational exposure to the different pesticides according crops, periods, and areas.

ATV mortality in the United States, 2011-2013

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OBJECTIVES:

The purpose of this study is to examine contributing factors of ATV fatalities through application of the Agent-Host-Environment epidemiological model. By analyzing the associations between contributing factors targeted intervention strategies may be identified.

METHODS:

US incident reports of ATV fatalities and injuries between 2011 and 2013 were obtained from the Consumer Product Safety Commission (CPSC). Each report was read and coded based on information available in the narrative incident report. Descriptive statistics were obtained for the coded variables and Chi-Square Automatic Interaction Detector (CHAID) analysis was performed to identify associations between predictor variables.

RESULTS:

A total of 1,230 incident reports were obtained and, after data cleansing, a total 1,193 fatality reports remained. While only 12% of cases occurred on farms, the calculated mortality rate in the farming population (.62 per 100,000 population/year) is over four times higher than the overall mortality rate in the United States (.13 per 100,000 population/year). Descriptive statistics showed low helmet use (11.85% of fatal cases) and high use of alcohol and drugs (84.2% of fatal cases).

CONCLUSIONS:

Baised upon the results of the CHAID for helmet use the variable most associated with helmet use is location type, with users on the farm, home or street less likely to wear helmets than other location types. Hypothesized reasons for this low rate of helmet use, especially in the loaction types of farm and home, are: preceptions of helmets being exclusively for recreational riders or that helmets are cumbersome and make performing occupational activities difficult, and the presence of legislation exemptions for argricultural users.

By modeling and categorizing risk it is possible to develop targeted solutions to the root cause of the hazard. Modification of user behavior is necessary to negatively trend the ATV injury rate and can be attempted using education, training, experience and legislation.

Pesticide exposure and health-risk profiles for re-entry activities in mountain vineyards

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Objective

Define an exposure and risk profile for occupational exposure to pesticides during re-entry activities in viticulture using an approach based on the analysis of data collected from crops treated with penconazole.

Material and Methods

Six workers were monitored while doing re-entry activities in a vineyard sprayed with the fungicide penconazole less than 48 hours earlier. Dermal dose was monitored by the application of passive dosimeters (pads) and by collecting the hand wash liquid (water and isopropyl-alcohol 20%). Concentrations of penconazole and of its metabolite PEN-OH were measured in urine samples collected during the 24 hours following the beginning of working activities. Risk assessment is reported as ratio of systemic dose and *Acceptable Operator Exposure Level* indicated in the authorization dossier of penconazole.

Results

Pads on the back were the most exposed, followed by those on lower limbs. Proportionally to the surface, the back has also received the greater amount of active substance, followed by the upper limbs. Hands determine 5,53% of total exposure, but their level of contamination is more than three times higher than that of the body when compared to the represented surface. No worker exceeded the maximum level of individual risk (median percentage of AOEL's saturation=1,10%). The absorbed dose and the AOEL's percentage of saturation were well correlated with the values of urinary excretion (considering penconazole and its metabolite PEN-OH); correlation values are respectively $r=0,8217$ and $r=0,9230$. This allows to estimate a level of excretion of the biological indicator of exposure corresponding to the assumption of AOEL's dose saturation (value called "*Equivalent Biological Exposure Level*").

Conclusions

This study provides risk assessment for re-entry activities and estimates, from data collected in real conditions of exposure, a provisional biological exposure limit useful to interpret data from biological monitoring of workers exposed to penconazole.

Characterization of exposure to vibrations in different agricultural tractors

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OBJECTIVES: The study aims at evaluating the levels of exposure to vibrations in three categories of tractors, representative of different wears and levels of technical obsolescence. Data have been collected with tractors in stationary conditions, in order to evaluate only the engine-generated vibrations.

METHODS: Three wheeled tractors has been considered for the study: one very old (built in 1988), provided with a mechanic suspension seat; one intermediate (2010), provided with a mechanic suspension seat; and one very new (2015), provided with a pneumatic suspension seat and with a front axle suspension. Tractors have been selected in order to represent typical brands, models and gear in Italian tractor. During measures, the same operator sat on the driver's seat; when the option was available, the stiffness of suspension seat was regulated on the base of operator's weight. Measures have been performed with a triaxial accelerometer, inserted in a semirigid rubber plate placed on the plane of the seat, considering different engine speeds.

RESULTS: We measured the highest levels of vibrations in all the axes in the old tractor, and the lowest in the most recent one. Vibration levels were generally under $0.05/0.06 \text{ m/s}^2$. In transversal axis and at lower speed, vibrations level was 0.2 m/s^2 : this is the highest level we measured in stationary conditions.

CONCLUSIONS: In stationary tractors, the only source of vibrations is represented by the engine function. Our data suggest that the highest levels of vibrations are observed in the oldest tractors, very likely due to reduced balancing of the engine brought about by the prolonged use. The lowest levels of exposure have been measured in the most recent built vehicles. The results of our study confirm the recommendation of renovating the machineries of the agricultural enterprises, or at least doing periodical maintenance of the tractors. Moreover it is important to adjust the seat in base of the driver's weight in order to obtain a greater vibration attenuation.

Characterization of noise in three different types of wheeled tractors

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OBJECTIVES:

This study was conducted to measure the level of noise exposure in three wheeled tractors from different manufacturers: One very old (registered in 1988), one intermediate (registered in 2010) and one very recent (registered in 2015). The intermediate and the recent tractors were equipped with a soundproof cockpit roll-bar with soundproof protection (ROPS). The old tractor was equipped only with ROPS and a simple tin roof.

METHODS:

The measurements were carried out in stationary conditions, so as to consider only the noise produced by the engine to the various engine rpm. The characterization was performed in a field of 100 m, and the measurements were performed at a distance of 7,50 m, from the different sides of the tractor (left, front, right and rear) increasing from time to time the different revolutions of the engine. It was then measured the noise in the right ear and the left ear at a distance of 10 cm so as to evaluate possible changes in the noise at different engine revolutions.

RESULTS:

Noise levels measured on the old tractor were between 80.5 and 93.6 dB (A) (right ear) and between 79.5 and 93.1 dB (A) (left ear). The characterization on different sides of the tractor was as follows: right side 65.4 to 84 dB (A), front: 66.2 to 83.4, left and rear side: 66.1 to 82.1 dB (A) and 61.2 to 74.6 dB (A) respectively. In the intermediate age tractor, with soundproof cockpit, noise levels were between 66.6 and 81.4 dB (A) (right ear) and 67.6 and 81.9 dB (A) (left ear). Results of characterization were the following: right side 68 to 83.7 dB (A), front: 65.9 to 85.7 dB (A), left and rear side: 67.8 to 86.2 dB (A) and 61.2 to 76.9 dB (A) respectively. In the new tractor equipped with soundproof cockpit, the results were: 63.1 and 76 (right ear), 61.4, and 76.3 (left ear). The characterization on different sides of the tractor provided the following results: right side 66.2 to 82.2 dB (A), front: 65.3 to 82.9 dB (A), left and rear side: 65.4 to 85.3 dB (A) and 62.5 to 76.2 dB (A).

CONCLUSIONS:

In older tractor, sound levels were comprised between 93.6 to 93.1 dB (A); this means the possibility of approaching or exceeding the EU upper value of action of 85 dB (A), even for short exposure periods. In the intermediate age tractor, sound level resulted in the order of the lower action level, even in case of short durations of exposure. As for the new tractor, sound exposure did not reach the lower action level. Our data permit to create noise exposure profiles for different kind of tractors and suggest the need, in case of use of old machineries, of wearing hearing protection, or is adding a soundproof cockpit. Since the levels of noise depends also on the quality of maintenance of the machineries, periodical maintenance intervention are recommended.

Toolbox talks: development of a dairy training curriculum

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OBJECTIVES:

Dairy parlors have seen major industrialization over the past four decades to mirror increasing herd size. This trend correlates to a changing worker population, in the United States largely immigrants working 8-12 hour shifts characterized in the milking parlor by repetitive tasks often leading to musculoskeletal disorders. No longer small family businesses, large dairy operations often fail to implement comprehensive training appropriate for a predominately non-English speaking population. The objective of this study is to educate dairy workers comprehensively concerning all facets of dairy practice, management, health, and safety.

METHODS:

Pulling from the specialties such as animal husbandry, zoonotic epidemiology, and ergonomic risk assessment, a toolbox of ten training sessions is being developed to properly equip Latino dairy workers regarding the major components of dairy safety and health. These talks are designed as a ten week course of 15-minute weekly training sessions on various subjects, to be given at shift change to all dairy workers in three South Dakota dairies. Surveys are additionally administered to assess subject proficiency in weeks one, five, and ten, extending the training sessions of those weeks by 45 minutes.

RESULTS:

Survey results will be analyzed in order to demonstrate the efficacy of the training sessions regarding subject materials. The resulting training curriculum will be well suited to future dairy management implementation.

CONCLUSIONS:

For an effective “one health” approach to dairy health, all team members must be educated thoroughly concerning their own occupational well being as well as the intricacies of cow health and dairy production. Moreover, training must be adapted to the cultural background of employees for effective dissemination.

Assessment of noise annoyance on the workers in Olfin Factory, Mahshahr port, Iran

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Introduction

Noise pollution is one of the most prevalent environmental pollutions resulted from industries. The aim of present study was to assess the level of airborne noise sensitivity and annoyance on the worker in petro-chemistry factor, which is located in south of Mahshahr port, which is an economically active area in Iran. This large size industry (110.000 m² area) produces Polymer materials. Main sources of noise pollution are from Turbans, compressor houses and furnaces. 98 workers are working in that factory.

Materials and Method:

Standard method ISO 9612 was used for noise monitoring. Sound level meter monitoring CEL 450 and Dosimetry CEL 320 Models (Made in England) and a standard questionnaire were used. 62 stations were selected by simple random sampling And 2828 samples were collected. Safe and unsafe zones were shown by using Arc GIS software version 10. 98 questionnaires were completed and collected by workers. SPSS software version 19 was used for statistical analyzing.

Results:

Maximum, minimum and mean of SPL were 99, 60 and 75 dB (A), respectively. In 494 out of 2828 sample points the level of noise was more than 85 dB (A). 17%, 63% and 20% of sampling points were in hazard, precaution and safe areas respectability. Around 51% of workers were highly/very highly annoyed of noise in their workplace. Loss of inner peace was the most prevalent non-hearing of noise on workers. There was a significance association between mean SPL and workers annoyance, age, sleeping disorders, fatigue, and ear tinnitus as measured by Chi square test.

Discussion and conclusion:

This study showed that the level of noise and annoyance was high among workers. In some points the level of noise has reached to 90 dB (A). This showed the importance of noise control measures to conserve the health and safety of workers.

Key words:

Noise monitoring, annoyance, Petrochemical factory

Assessment of agricultural pesticide exposure by Pesticide Exposure Examination Survey among Korean agricultural workers

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OBJECTIVES:

Our study purpose were to evaluate pesticide exposure of occupational agricultural working category according to before and after pesticide spraying.

METHODS:

A total of 17 male farmers were recruited to participate in pesticide exposure examination survey (PEES). We were to assess urinary metabolites excretion concentration for 4 types of organophosphate (OP) and pyrethroids (PR), respectively (OP metabolites: dimethylphosphate, dimethylthiophosphate, diethylphosphate, and diethylthiophosphate; PR metabolites: cis and trans-2, 2-(dichlorovinyl)-2,2-dimethylcyclopropane carboxylic acid, cis-2, 2-(dibromovinyl)-2, 2-dimethylcyclopropane carboxylic acid, and 3-phenoxybenzoic acid). Urine samples were collected four times a spot-urine (before pesticide spraying, the next morning after pesticide spraying, and the next morning after the farm work after 24 and 48 hours pesticide spraying). The urine metabolites were compared with each measurement.

RESULTS:

This survey is still in progress and the results will come out on August 2015.

CONCLUSIONS:

Even though this study sample size was small and including for only a few types of pesticide metabolite results, it will be expect to provide the clue related with agricultural pesticide exposure.

Health and safety policies in rural areas

People's Attitude Toward Eating Habits and Health in Japanese Rural Area - Analysis of Survey Results and Their Commitment to Agriculture -

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OBJECTIVES:

As part of the special study project of the Japanese Association of Rural Medicine (JARM), a questionnaire survey was conducted to probe into the attitude of rural people toward their eating habits and health.

METHODS:

Most of the people surveyed had received health checkups carried out by medical facilities affiliated with the JARM.

RESULTS:

Questionnaires were distributed to a total of 5,397 people (2,588 men; 2,809 women) living in and around provincial cities. Mean age was 53.4 for men and 53.8 for women. More than half of those questioned were farmers or had experienced in farming. Eighty percent of the total said they felt happy, and those who felt short of exercise also represented 80%, but with advancing age, the ratio decreased. Those over the age of 70 who said they had a habit of taking exercise made up as high as 60%. Many said they were satisfied with food in terms of quantity, but not a few people expressed uneasiness about food safety, dietary life and supply of food. Regarding favorite foodstuffs, many gave rice, vegetables and dairy products. There was a tendency for older people to eat meat less. It was found that, with increasing age, people took to eat dairy products, soybeans, vegetables, fruits and fish were ranked among the most popular foodstuffs. Respondents with a higher score on the attitude toward local production for local consumption and commitment to agriculture were interested in social participation, eating breakfast, securing food supply and purchasing foodstuffs at outlet stores run by local agricultural cooperatives.

CONCLUSIONS:

From these findings, it was suggested that many residents in and around provincial cities oriented themselves to healthy eating habits and lifestyle, and were very interested in social participation, local economy, agricultural production and consumption of local farm produce.

Legal, statutory and institutional framework of the management of pesticides in Benin: which impact on the users behaviors?

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BACKGROUND: If the legal and statutory measures enable to reduce the incidence of the effect of pesticides on human health and on the environment in the developed countries, it does not seem the same in african countries in general and in Benin in particular. Our countries still show high rates of harmful effects of these products on human health and on the environment.

OBJECTIVES: We aimed through this study to describe the legal and statutory framework of management of pesticides in Benin.

METHODS: After a review of literature of the legislative and statutory texts related to the management of pesticides, and through a cross sectional study, we questioned 422 farmers selected by random sampling. The data collected have been processed and analyzed using Epi-Info Version 3.5.1. The results of the quantitative variables are presented as mean $\pm$ SD and categorical variables such as percentage. Categorical variables are compared using chi-square tests with statistical significance taken at $p < 0.05$.

RESULTS: On the national level the legal and statutory framework comes through various texts of laws, their orders of application and many other measures intended for the achievement of the objectives that the country set regarding management of persistent pollutants. Concerning the varieties of pesticides used over the period of study, there are some which are unlisted in the WHO classification, nor in the list of authorized pesticides. Concerning the distribution network, it developed an unofficial circuit of supply from the smuggled networks from Nigeria and Ghana. Old stocks of obsolete pesticides are also found themselves with the producers. Contrary to what is recommended, they were only 5 % to have weekly been visited for the supervision. The majority of the investigated reused the empty packagings

CONCLUSION: The reasons of this situation can be looked for in the performance of the statutory devices, their applications and the follow-up of these.

Mid-career change of medical doctors in Japan - Specialists to Generalist-

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OBJECTIVES:

In Japan, most physicians providing primary care service have been trained and qualified as specialists before focusing on primary care at middle age. This mid-career change may be unique in the world because specialists tend to earn more and have greater prestige than primary care physicians. However, the Fee Schedule, that sets the fee and conditions of payment for virtually all services in Japan, prices services for primary care relatively higher than those of specialists. However, whether the physicians who decide to switch to primary care have acquired the skills needed in primary care has not yet been examined. We will conduct a survey of the physicians providing home-based care to elucidate the process on how they came to focus on primary care and whether they possess the skills required.

METHODS:

A list of the physicians who provide home-based care in clinics or in hospitals will be made based on the register of clinics and hospitals providing home-based care supporting services. The questionnaire consists of age and sex, their career before starting to provide primary care, basic skills as generalists and the process as to how they acquired these skills. The questions will be modified from the examination of the Japanese Family Medicine Society and the American Board of Family Practice, and their answers will be compared with those of their members. This questionnaire will be mailed to those listed. This study will be conducted in Nagano Prefecture. However, a pilot study will be conducted by interviewing representative samples in advance.

RESULTS:

We will present the results of the pilot study. We will focus on how the skills of those interviewed compares with those of the newly established qualification for family medicine specialists.

CONCLUSIONS:

To be presented at the meeting

The possibility of verbal autopsy to clarify the causes of death in the HIV positive patients and to improve the services in rural setting in Zambia

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OBJECTIVES:

Low-income countries in sub-Saharan Africa have high prevalence of HIV and most of their deaths happen in their home or close clinics. Consequently, the causes of their death were not clarified.

The cohort study was conducted to follow up HIV positive patients in Mumbwa district in Zambia to compare the patients who can attend district hospitals (DH) that can provide every day and rural health center (RHC) supported by mobile ART team once in two weeks. As a result, 352 patients were totally followed. Twenty nine cases were the death in RHC (29/177 cases), and Seventeen cases died in DH (17/158) for 2 years. Verbal autopsy was planned to make clear main causes of "Death" cases in rural setting. Furthermore, we expected that grasping of causes of death cases could lead to improving of ART services.

METHODS:

The questionnaire for verbal autopsy was developed based on the 2012 WHO verbal autopsy instrument. The list of 49 death cases was prepared from the cohort. Verbal Autopsy to families or neighbors of each death case was conducted confidentially with the cooperation of community health volunteers through visits or calls to them. The questionnaires were collected and analyzed to clarify the expected reasons of those death cases using the modified instrument.

RESULTS

Forty-three cases could be surveyed with verbal autopsy (43/49 cases). The major reasons of deaths were tuberculosis (14/49), chronic diarrhea (8/49) and HIV wasting (6/49 cases).

9 cases of 14 TB suspected patients could not get the exams. Most of diarrhea suspected patients were prescribed with only antibiotics.

Conclusion

The verbal autopsy could clarify the main reasons of death cases of HIV patients with certain accuracy. Moreover, the findings from verbal autopsy could improve HIV clinical services in rural setting.

REFERENCES:

2012 WHO verbal autopsy instrument

Differences in the number of elderly individuals newly certified to require long-term care between basic checklist respondents and non-respondents

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Objects and Methods

Among approximately 8,000 elderly citizens of X City, changes in the number of individuals, newly certified to require long-term care, were observed from 2008 to March 2013. The aggregated totals of these individuals and associated factors were evaluated. The rates of care-needs certification were compared between two cohorts; specific health checkup examinees / basic checklist respondents and non-examinees / non-respondents.

Results and Conclusions

1. Support Required 1, Support Required 2, and Long-term Care Required (level 1) certified individuals accounted for approximately 80% of newly certified individuals aged 65–74 years. Newly certified individuals aged 75 years and over had similar results with 37.2% certified Support Required 1, 19.4% certified Support Required 2, and 22.9% certified Long-term Care Required (level 1).
2. Of the 7,820 specific health checkup examinees / basic checklist respondents, 1,280 were newly certified to require long-term care (16.4%), compared to 7,878 (26.9%) of the 29,234 non-examinees / non-respondents. Therefore the latter cohort had a significantly higher rate of individuals who were newly certified to require long-term care.

The status of safety and health in agriculture of South Korea

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Objectives: The purpose of this study is to look into the research and development programs for farmers' health and safety in South Korea. The development of agricultural technology in Korea has caused health and safety problems as well as reduced the needed labor force. For farmers have become exposed to various risks from many types of pesticides, farm machinery and agricultural facilities. Another aspect is rural communities became already aging society as the result of industrialization. These elderly farmers have been working a lot of time in poor working conditions. Farmers' long-term health problems are caused by agricultural activities, like keeping the awkward postures. According to a state-approved sample statistics by RDA, more than one day absence, the rate of work-related injuries for farmers is approximately 3%. And it is around 5% of the prevalence of work-related diseases of more than one day leave of working. In order to prevent occupational injury and disease of farmers, the Rural Development Administration has conducted research and development programs such as farm injury monitoring, exposure assessment on occupational hygienic risk factors, ergonomic tools, simulator training for agricultural tractors, farm work experience program, personal protection equipment and others.

Methods: Most recently, the Ministry of Agriculture has designated seven Agricultural Safety and Health Centers at the University Hospital to address the health problems of farmers and is trying to begin the farmers' social security system as insurance for occupational injury and disease.

A Health Promotion Strategy for Rapidly Aging Communities: The Activities of the Awata Health and Community Development Association's "Campaign for Improved Health"

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OBJECTIVES: The "Awata kenkō machizukuri kai" (the Awata Health and Community Development Association), established in Higashiyama Ward's Awata school district, continues to hold bi-annual events through the activities of its member organizations as part of a "Health Care Town" project to "revive community ties, and cultivate the potential for the community to promote feeling lifestyles."

METHODS: The study involved action research, and provided a detailed account of the activities implemented as part of the "Awata chiiki kenkō-ryoku appu daisakusen" (Awata Campaign for Improved Community Health).

RESULTS: The numbers of participants remain relatively unchanged since the first event, while in terms of the gender ratio, women have accounted for 60%–70% of participants on each occasion. In terms of the participants' age, the majority of participants were elderly persons in their 70s.

CONCLUSIONS: The member organizations of the Awata Health and Community Development Association (including the Residents' Association, the Women's Association, the Seniors' Club, the Kyoto University and Kyoto Prefectural University of Medicine, the Regional Comprehensive Support Center, and the Preventive Care Promotion Center) have understood their respective roles and functions through the repeated experience of conducting their activities, and have been holding discussions with the objective of securing new members. To support life in an aging urban neighborhood wherein the function of the community is declining, we believe that it will be beneficial to share functions among existing organizations and multiple other bodies, and to offer hands-on activities that can strengthen relationships among local residents. In the future, we plan to perform an evaluation of activities implemented as part of this project.

Improving the health of aged rural workers

Quality of Life of elderly people on a remote island: a comparison between urban and rural areas

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Objective

This study was conducted to clarify the difference among Quality of Life (QOL) of elderly people living in an urban area and in rural areas on a remote island.

Method

Surveys were conducted between September 2013 and February 2015. By means of a questionnaire, 51 elderly residents on A Island, 51 residents in B City, and 54 residents in rural Area C were interviewed. QOL was evaluated from one to five points using a partial modification of WHO/QOL26 in accordance with the actual situation in the above three areas. The results were analyzed by *t*-test.

Results

Respondents on A Island included 51 residents (18 males and 33 females), with ages ranging between 65 and 88 and averaging 77.2 years. Respondents in B City included 51 residents (17 males and 34 females), with ages ranging between 65 and 89 and averaging 76.0 years. Respondents in Area C included 54 residents (25 males and 29 females), with ages ranging between 65 and 85 and averaging 74.1 years. Of these residents, 96.1% on A Island, 74.5% in B City, and 90.7% in Area C were receiving medical treatment. The residents on A Island scored between 2.15 and 4.04 on their QOL evaluation, the average being 3.20, the residents in B City scored between 2.31 and 4.69, the average being 3.76, and the residents in C Area scored between 2.77 and 4.81, with the average was 3.68.

The QOL scores were highest in B City, followed by Area C and B Island, with the scores for B City being significantly higher than for A Island.

Conclusion

The significantly higher QOL scores in B City than on A Island could be the result of geographical conditions, transportation facilities, secure living, fewer residents in need of medical care, and job satisfaction and competence.

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Participatory Action Oriented Training for Improvement of Health and Safety of Korean Farmers

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Objectives: This study was conducted to report the experiences of Participatory Action Oriented Training (PAOT) as a tools for empowerment training for promoting work-related health and safety of Korean farmers. We would like to introduce the application of participatory training method and report our experiences in a rural community in Korea.

Methods: The Korean version of PAOT manual and action checklist were developed on the basis of the original English version of the training materials, a questionnaire survey of agricultural health and safety professionals, and a brainstorming conference. Using these training materials, a one-day Korean PAOT program was developed. All participants had to have established their own health and safety improvement action plans as final task of workshop.

Results: From year of 2007 to 2014, we conducted 50 times PAOT workshop and 1,045 farmers participated. The mean self-estimated satisfaction score of the participants using questionnaire survey was greater than 90%. The average number of action plan proposed farmers were 20.7(male 10.8, female 9.9) in each workshop. They had proposed total 1,022 short term action plan and 452 long term plan. By follow up visit of famer's house, it had been proved that 64.7% of action plans were implemented into real.

Conclusions: A Korean PAOT program had been successfully developed and applied to Korean farmers. Although more studies are needed, it is expected that the PAOT will greatly contribute to the improvement of agricultural working conditions and health and safety through the use of farmers' self initiatives.

Gender Differences in the Occurrence of Nonfatal Agricultural Injuries among Farmers in Fukuoka, Japan

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BACKGROUND:

The lack of information regarding nonfatal agricultural injuries has been recognized as an obstacle for effective injury prevention. The aim of this study was to describe gender differences in the pattern of nonfatal agricultural injuries between the years 2008 and 2009.

METHODS:

Farmers' compensation claims are utilized to determine the distributions of mechanism (machinery, non-machinery, and traffic), type, source, cause, body part, place, work contents of injury and hospitalization. Agricultural injuries were identified using International Classification of External Causes of Injury (ICECI). The Statistical Analysis System (SAS) was used for all statistical analyses. Study variables were compared using the Mantel-Haentzel chi-square test.

RESULTS:

A total of 2,729 (1,921 males) farmers' compensation injury claims was analyzed. There were approximately 9 times as many nonfatal agricultural machinery related injuries for males compared to females (536 and 58, respectively). The most common machinery injuries were cut with a rotary blade (31%) for males and struck by machine (24%) for females in 65-89 years of age group. The males-females ratio of non-machinery injuries averaged 2:1 (1,293 and 676, respectively). For both males and females in 65-89 years of age group, the main source of non-machinery injuries was due to the slope (18% and 22%, respectively), the main type was falling/slipping down (29% and 45%, respectively), the leading cause was fracture (28%, 45%, respectively), and the main work content was harvesting (51% and 38%, respectively). Female farmers had a greater risk of prolonged hospitalization (more than 30 days) compared to males ($p<0.01$).

CONCLUSIONS:

Gender is an important factor to consider in the interpretation of nonfatal agricultural injuries. A greater number of males were injured, when the occurrence of injury was categorized with machinery and non-machinery. Further research will be needed to understand the role of differential job-tasks within agriculture in explaining the risk difference.

Development and Application of Participatory Mapping for Healthy Agricultural Village

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OBJECTIVES: We developed participatory mapping as a tool for empowerment training for promoting farmer's health and safety. We would like to introduce participatory mapping method and report our experiences of it's application process in Korea rural community.

METHODS: One day course participatory mapping workshop was performed among volunteer farmer who belong to 'safe farm zone' rural village. The schedule of workshop was started with orientation session followed by village rounding, good example presentation, drawing healthy village map, group map presentation. During the workshop, participants were requested to express their ideas and experiences about healthy and safe residential, working environment on their map.

RESULTS: Total 206 farmers (100 male, 106 female) were participated in participatory mapping. In each workshop, 34.3 farmers participated, and their mean age was 59year. In six workshop, participants proposed total 137 action plans. The action plans were improvement of co-working condition, building a facilities for relaxation, traffic safety facilities, residential environment improvement.

CONCLUSIONS: We can successfully developed and applicated participatory mapping as a tools for empowerment among Korean farmers. They expressed their ideas and thoughts about healthy and safer village as a action plan on the map. Some of action plan were carried out immediately after workshop.

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Factors Affecting Four-year Score Change of Frailty, Depression, Cognitive Function and QOL in Rural Elderly: A Retrospective Study

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Objectives: This is a study of retrospective cohort performed targeting 296 elderly people who were 65 or older as of 2009.

Methods: It is designed to compare changes in scores in frailty, depression, cognitive function, and quality of life that occurred for four years between 2009 and 2013 and analyze related factors.

Results: The scores in frailty, depression, cognitive function, and quality of life for the four years all registered significant difference. A correlation analysis shows that the changes in frailty score, depression score, and cognitive function score were significantly correlated with the change in quality of life score. As of 2009, the subjects were divided into those who were 74 or younger and those who were 75 or older, and a comparison of changes in their scores for frailty, depression, and cognitive function showed differentiation with the two age groups.

As for factors affecting cognitive function score, age (80 or older), diabetes, deterioration in frailty score, and deterioration in depression score were significant, while as for factors affecting quality of life score, drinking experience and deterioration in frailty score were statistically significant.

Conclusions: In order to promote health level and quality of life, future establishment of policy for elderly health and welfare would have to be customized to age, mental health, and physical health condition, and various mediation programs including elderly health project and mental health project will have to developed and provided.

Alteplase (rt-PA) therapy in old Japanese patients with acute ischemic stroke

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OBJECTIVES:

Propriety of rt-PA administration for old patients with acute ischemic stroke is still controversy. In Japan we have been required more careful judgment when we use rt-PA in over 80 years old patients. We in this study show the outcome of the rt-PA therapy in old patients in our hospital.

MATERIALS and METHODS:

Sixty-nine patients being administered rt-PA therapy in between January 2010 and December 2014 were enrolled in this study. Their age, NIH stroke scale (NIHSS) at the hospital visit, causes of infarction, time to hospital arrival (AT), time to start of rt-PA infusion (IT) and modified Rankin Scale (mRS) at the time of outcome were reviewed retrospectively in their medical records.

RESULTS:

Twenty-six out of 69 patients were 80 or over 80 years-old. Twenty-three out of the 26 patients were cardiac embolism, and the mean of NIHSS of the 26 patients were 18.5. Mean of AT and IT in the 26 patients were 67.3 and 160.7 minute. In the outcome of the 26 patients, we noted good recovery (mRS: 0~2) in only one, bedridden state (mRS: 5) in seven, and death (mRS: 6) in five patients. In the dead patients we could not find any symptomatic bleeding events due to side effect of rt-PA therapy.

DISCUSSION and CONCLUSIONS:

The condition at hospital visit was more severe in old patients, and this might be related to the worse outcome in this study. However, since we could not find symptomatic bleeding events, rt-PA therapy was thought to be safe. Administration of rt-PA for old patients with acute ischemic stroke is safe, but the effectiveness is lower in this study.

Muscle skeletal risk

Ergonomic analysis of work-related hazards in older farmers: a comparison between Sweden and Italy

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OBJECTIVES:

The progressive aging of the workforce affects also the agricultural industry, with farmers often working well beyond their expected retirement age (1-3). The aging process is related to many physical and cognitive changes which can affect the interaction with the work environment and can give rise to new hazards and risks for older farmers (4,5). Agricultural machinery, in particular tractors, are a major source of discomfort and accidents (2,6,7). These issues can be properly investigated by adopting an ergonomic approach, which focuses on the *interaction* between humans and the other elements of a system. Based on these considerations, the present study aims at performing an ergonomic analysis of work-related hazards in two sample of older farmers in Sweden and Italy, two peculiar countries in terms of agricultural practices and accidents involving older farmers.

METHODS:

10 male farmers aged 65 and over in both Sweden and Italy will be involved in the study. A semi-structured interview will be administered to investigate: 1) Motivation and satisfaction toward farm work; 2) Perceived physical and cognitive workload, 3) Safety practices and previous accidents.

The interaction with the agricultural machinery will be assessed through: 1) The simulation of some working tasks involving the tractor, 2) A brief questionnaire about the comfort of the tractor cab.

Anthropometric parameters will be considered too, to evaluate the effects of human physical variability on the human-machinery interaction.

RESULTS:

Data collection started in May 2015 in Sweden. Later on a matched group of participants will be involved in Italy.

CONCLUSIONS:

The results of the study will highlight similarities and differences in work-related hazards between Swedish and Italian older farmers. Based on this, some considerations will be done about the prevention campaigns, training interventions and design solutions that it's possible to develop to improve health and safety of older farmers in the two countries.

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Prevalence of Osteoporosis and related Factors using Quantitative Ultrasound among Korean Women Farm Workers

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Objectives: The aim of this study was to investigate prevalence of osteoporosis and its related factors in Korean women farm workers.

Methods: The present study is a cross-sectional study. The study population consisted of 94 Korean women farm workers aged 38 years and older with BMD measurements using quantitative ultrasound at calcaneus. Prevalence of osteoporosis and its related risk factors were analyzed.

Results: Prevalence of osteoporosis in Korean women farm workers (range of age, 38–83 year-old; average age, 61.3 year-old) was 40.4% at calcaneus. Risk of osteoporosis was significantly increased with age; 60-69 year-old (OR, 18.50; 95% CI, 3.55-96.34) and ≥70 year-old (OR, 57.81; 95% CI, 11.32-295.20). After adjusting for age, risk of osteoporosis was significantly associated with annual household income below 20,000,000 Won (OR, 9.86; 95% CI, 1.03-94.34) and overweight (BMI, 23.0-24.9 kg/m²) (OR, 0.18; 95% CI, 0.05-0.72).

Conclusion : Prevalence of osteoporosis in Korean women farm workers was high and risk of osteoporosis was significantly associated with age, household income and BMI.

Risk Factors Associated with Lumbar and Femoral Bone Fractures in postmenopausal Japanese Women

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OBJECTIVES: The purpose of this study was to analyze risk factors affecting fractures of the femoral neck and lumbar spine in postmenopausal women.

METHODS: The subjects were consisted of three groups (A: with fracture in femoral neck, B: with fracture in lumbar spine, and C: age-matched control without fracture) The numbers of each groups were 150, 112, and 101 respectively, and average ages were 74.8 ± 0.7 , 73.1 ± 0.7 , and 74.0 ± 0.6 respectively.

Bone mineral densities (BMDs) of lumbar spines (L2-L4) and femoral necks were measured by the DXA. Several factors those are thought to be affecting bone fractures such as ages, anthropometric factors, menses-related factors, alcohol drinking, tobacco smoking, past history of bone fracture, biochemical test values, and the presence or absence of complications and anamnesis were investigated. Comparing the differences of average values or prevalence values among three groups, effects of these factors on bone fractures were examined.

RESULTS: Past history of bone fractures were significantly prevalent in A and B groups. Tobacco smoking rate was higher in group B, and alcohol drinking rate was higher in group A. Femoral BMD was lower in group A, and Lumbar BMDs were lower in group A and B. Serum albumin levels were lower and blood glucose levels were higher in group A and B. Prevalence rate of diabetes mellitus was higher in group A, and prevalence rates of brain diseases were higher in group A and B. Blood pressure levels were higher in group A and B.

CONCLUSIONS: Past history of bone fractures, habit of tobacco smoking, alcohol drinking, low BMDs, malnutrition, complication of diabetes mellitus and brain diseases, and hypertension are risk factors of bone fractures in these postmenopausal women.

Internal fixation for displaced femoral neck fracture associated with poorly controlled diabetes mellitus

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OBJECTIVES:

Hemiarthroplasty has been recommended for displaced femoral neck fracture. Surgical site infection is a serious postoperative complication following hemiarthroplasty. In patients with diabetes mellitus (DM), the infection rate is high. We report cases of internal fixation for displaced femoral neck fractures associated with poorly controlled DM.

METHODS:

We identified fifteen patients with displaced femoral neck fracture with poorly controlled DM. The implant used were the Dual SC screw system (DSCS®) (Kisco) ,6 hips and the Hansson pin system (Stryker) , 9 hips.

We investigated HbA1C (NGSP)(%) level, existence of union at fracture site, interval between the initial operation, and HbA1C(NGSP)(%) level at salvage operation.

RESULTS:

Average HbA1C was 8.5% (range: 7.1-10.5) at the time of injury. We got fracture site union in seven cases. We need salvage operation in six cases. Interval between the initial operation was six months in average. HbA1C level at salvage operation improved to 7.1% in average.

CONCLUSIONS:

We performed internal fixation for displaced femoral neck fracture associated with poorly controlled DM. Even when the fracture did not unite, we had sufficient time to control the patient's DM. In cases of poorly controlled DM, internal fixation is one of the options for displaced femoral neck fracture.

Occupational risks assessment and prevention

Fine dust aerosols toxicokinetics in organism

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Objective is to study fine dust aerosols toxicokinetics in organism.

Methods. The polymetallic dust consists of free crystalline silica (53.7%), copper (8%), arsenic (0.04%), antimony (0.003%) and titanium (3%). It receives approval of Local Ethics Committee to conduct the experiment on white male rats by dynamic inhalation with polymetallic dust with 10 mg/m³ concentration during 1, 3, 40, 90 and 180 days. Experimental terms correspond to 40 days, 4 months, 5, 10 and 20 years of working in dusty conditions.

Results. The highest silica deposition in rats' lungs (62%) occurred in the early experimental stages with reduction to 40 days (22%) at the continuing elimination ability via respiratory system (45%). It indicates the possibility of dust aerosols penetration while keeping mucociliary transport and phagocytosis. The reduction of elimination ability via respiratory system from 90 days (34%) indicates the worsening of mucociliary transport, phagocytosis activity and penetration activation into interstitial lung tissue.

At 1 day in the circulating rats' blood 29% of silica entering the body was revealed with clear reducing in further terms. It demonstrates the dust aerosols penetration into pulmonary interstitial tissue and their entry into bloodstream. These aerosols spread to internal organs and accumulate there decreasing silica amount in circulation blood.

By 40 days the silica deposition has increased in rat liver reducing its content in other gastrointestinal organs (85%) in absence of the sharp increasing their elimination with feces. It indicates the insolvency of detoxifying liver function.

Aerosols fall into the kidney tissue with the blood. By 40 days renal elimination function and intensive reabsorption have decreased reducing silica elimination with urine.

Conclusion. From the lung tissue by penetration fine dust aerosols reach the blood and spread the internal organs, and their elimination from organism is not only via inhalation but also via kidneys and gastrointestinal tract.

Risk factors and children injuries while performing agricultural work in the Požega-Slavonia County, Croatia

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OBJECTIVES:

The aim of this study was to determine current health and safety conditions of children who live and work in farm households in Požega-Slavonia County and to detect hazards that occur while performing agricultural work, in order to introduce specific health and safety measures that could help in health protection, as well as in eliminating and reducing injuries.

METHODS:

The study was conducted from September 2011 until May 2012. Data on agricultural activities performed by children, most common injuries and use of protective equipment were collected through a questionnaire.

RESULTS:

The results show that 52.1% of 188 children performed various agricultural activities on daily basis. While performing agricultural work, 30.6% of respondents suffered injuries characterized as minor and severe. The greatest number of injuries was caused by mechanical force while working with agricultural machinery, various hand tools and during work with animals.

CONCLUSIONS:

In conclusion, safety measures and regulations do not apply to children who are members of agricultural households. The existing legislative cannot regulate this problem because children are not officially employed. The presented data on these children's health condition point to the need of expanding the study to the health status of children in rural areas of Croatia, the impact of agricultural work on the occurrence of injuries and illness, as well as assessment and adoption of safety and health measures in order to ensure safer working environment and protection of their health.

Rural-urban differences impact the number of unintentional injuries in elderly Korean adults

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OBJECTIVES: The objective of this study was to evaluate the impact of rural-urban differences on the prevalence of unintentional injuries in elderly Korean adults. Furthermore, we evaluated the impact of sex and types of injury on the rural-urban differences in the number of unintentional injuries.

METHODS: This study included 49,890 subjects (20,304 males and 29,586 females) aged 65 years or older from the 2009 Community Health Survey (CHS). Unintentional injuries were defined as any injuries that were not deliberately caused by another person and required medical attention during the past 12 months. We performed survey logistic regression to determine the association between residential area and unintentional injuries, after adjusting for age and socioeconomic status.

RESULTS: The age adjusted prevalence of unintentional injuries were higher in rural (47.0 per 1000) than in urban (51.9 per 1000). When we stratified by sex, rural residence was associated with an increased risk of unintentional injuries in men (OR = 1.24, 95% CI = 1.05 – 1.47) but not in women (OR = 1.03, 95% CI = 0.90 – 1.18). In the subtype-specific analysis, rural residence was associated with an increased risk of traffic injuries (OR = 1.83, 95% CI = 1.33 – 2.51) and collisions (OR = 1.73, 95% CI = 1.13 – 2.63) in men but not in women while rural residence was associated with increased risk of animal bites (OR = 3.77, 95% CI 1.48 – 9.60) in women but not in men. However, residential area was not associated with risk of stabbings, burns and poisoning in both sexes. These association were attenuated after adjusting for socio-economic status.

CONCLUSIONS: From these results, we conclude that residents from rural areas are at a higher risk of having unintentional injuries compared to residents from urban areas. Furthermore, the associations we observed were gender-specific and injury subtype-specific. Therefore, from these results we suggest that gender-specific and residential area-specific strategies should be implemented into community programs to prevent injury.

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Social capital among people with arthritis in Rural Area

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OBJECTIVES: Recent studies have found that social capital and social connectedness are important to the health. However, there is little research examining social capital and the perception of social connectedness among people with arthritis. To examine and compare perceptions of social capital (network diversity, civic engagement, community belonging, trust in others and the health care system) in three groups of adults: 1) those with arthritis; 2) those with arthritis and with activity limitations; and 3) those without arthritis.

METHODS: We analyzed data from the 2013 the Community Health Survey (CHS). Three mutually exclusive groups were created consisting of individuals with: 1. Arthritis (i.e., self-reported physician diagnosis of arthritis); 2. Arthritis with activity limitations (AL) (i.e., AL reported as limiting the amount or kind of activity at home, work, school or other activities because of a physical or mental condition or health problem); 3. No arthritis. Social capital was assessed by measures of community belonging, trust in others, confidence in the health care system, civic engagement, and network diversity.

RESULTS: Arthritis with and without activity limitations was reported by 12.0% and 4.7% of the sample, respectively, with increasing frequency with age. No significant differences between the three groups were found for network diversity, civic engagement, or community belongingness. However, people with arthritis and activity limitations were significantly less likely to report being trusting of others and individuals with arthritis both without and with activity limitations had significantly less confidence in the health care system than those without arthritis, with the arthritis and activity limitation group having the lowest confidence.

CONCLUSIONS: Although people with arthritis (with or without activity limitations) felt equally well connected to the community, lower levels of trust of others and confidence in the health care system they report are concerning. Future research needs to examine the link between trust and health as well as whether there are implications for seeking or adhering to the health care treatment and disease management.

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Policies and approaches for improving the access to health care in rural areas

Analysis of Medical Expenses Structure for Patients on Percutaneous Coronary Intervention by Medical Security Type

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OBJECTIVES:

This study was analyzed to investigate the differences of medical costs by medical security type and the influential factors on the medical expenditure of the heart diseases patient's percutaneous coronary intervention in South Korea.

METHODS:

The subjects of study are the 1,904 patients who were on the PCI list of a medical university hospital from 1 January 2011 to 31 December 2012, since the total medical cost should be included benefit medical cost and non-benefit medical cost. It is analyzed by SPSS statistical program and Research Ethics Review has received from Chungnam National University Hospital Clinical Trials Review Committee.

RESULTS:

The total medical cost of the national health insurance is higher than the medical aid patients, but there was no significant difference.

The itemized total medical cost, medical aid was significantly higher in physician fee and admission charges, meals, medication and injection fee but, the charges for an operation, non-benefit medical cost, optional medical cost was significantly lower.

The daily total medical cost to figure out the medical service utilization intensity, national health insurance is higher, but there was no significant difference.

The itemized daily total medical cost, medical aid was significantly higher in meals and, significantly lower in non-benefit medical cost.

The analysis on factors influencing PCI patient's medical cost by hierarchical regression analysis model, the history of PCI, PCI lesion number, stent number, hospital stay, outcome, medical security type was significant.

CONCLUSIONS:

The medical cost showed different structure by medical security type in the treatment of severe diseases such as coronary intervention, and the medical security type is significant factor of the medical cost.

Thus, the medical aid patient has a low socio-economic status can be limited to expensive non-benefit and optional medical services utilization.

Current situation of severe motor and intellectual disabilities in a rural area, the Saku region of Nagano Prefecture

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OBJECTIVES:

Recent advances in pediatric medicine have led to an increase in severely disabled children that require medical care at home. Our aim of this study is to ascertain what kind of life they lead in a rural area, the Saku region of Nagano Prefecture.

SUBJECTS:

Severely motor and intellectual disabled children were defined as those who could neither take a standing position nor speak the meaningful words. We had a survey on 33 children (17 male and 16 female) aged less than 6 years (n=9), 7 - 15 years (n=19) and 16 - 18 years (n=5) who live in the Saku region. Thirty-two children spend their life at home and one has been institutionalized.

RESULTS:

Each primary disease causing their disabilities was asphyxia (n=7), congenital malformations syndrome (n=9), unknown intellectual disability (n=4), acute encephalopathy (n=3), Leigh encephalopathy (n=2), drowning (n=2), and each one of severe myoclonic epilepsy, trauma, Guillain-Barre syndrome, arteriovenous malformations, laryngitis and meningitis. Medical managements were performed, such as tracheotomy (n=10), larynx trachea separation surgery (n=4), ventilator treatment (n=3), gastrostomy tube placement (n=14) and routine nasogastric tube (n=1). Two cases regularly receive the visiting medical examination and care, and the rest do outpatient care. Twenty four children aged more than 6 years are enrolled in a school for disabled children and four of them receive educational support at home. As for the support in the region, the visiting nurses take care of 10 children, especially those who need medical care such as tracheostomy and gastrostomy. The short stay service and the day service of outpatient support after school are used by children, 11 and 19, respectively.

CONCLUSIONS:

Further enhancement of the short stay facilities and child day care service will be required for severely disabled children. We hope that a safe and comfortable society for all individuals in the near future can be created.

Examination of support needed to continue home care in the community (1): Differences in occupations and training of staff involved in home care

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OBJECTIVES: Home medical and nursing care are growing to cope with the shortage of convalescent centers caused by rapid societal aging. We examined how differences in occupations and training of home care staff affect support for continuing such care.

METHODS: A postal questionnaire survey was conducted on 1,010 staff members involved in home medical and nursing care (valid response rate, 50.9%).

Survey content: Sixteen types of support needed to continue home care were extracted from cases in which dying at home was realized following the continuation of such care (Tsukahara and Mizukami, 2014), and these were divided into the introduction (5 items), continuation (7 items), and terminal (4 items) phases of home care. The extent to which these 16 items supported home care continuation was examined using the 4-category method. The training topics consisted of 11 items, including the nursing care insurance system, home palliative care, and the community-based clinical path, and whether or not staff received training in these areas was examined.

Analysis: SPSS software was used for statistical analysis.

Ethical considerations: The study was conducted following review by the Jin-ai University Institutional Review Board.

RESULTS: A 2-factor analysis of variance (ANOVA) was first performed to examine whether the level of support differed in each of the phases of home care depending on the type of occupation (healthcare/social welfare) and extent of training (low group, 0-2 training courses taken; moderate group, 3-5; high group, ≥ 6). As a result, in the introduction and terminal phases, only main effects were seen for the type of occupation (introduction phase: $F(5.97)=0.015$, $p<.05$; terminal phase: $F(27.08)=0.00$, $p<.01$) and extent of training (introduction : $F(10.37)=0.00$, $p<.01$; terminal : $F(3.46)=0.03$, $p<.05$). In the continuation phase, a significant difference was seen only for the extent of training ($F(3.46)=0.032$, $p<.05$), with more support provided by the high group than the low group ($p<0.05$).

CONCLUSIONS: That is, those in healthcare-related occupations provided more support for continued home care than those in social welfare-related occupations, and support resulting in home care continuation increased with the number of training courses taken. During the continuation phase, no difference was seen according to the type of occupation; the only difference seen was for the extent of training.

REFERENCES: Differences in the type and extent of training affected support for continuing home care.

Examination of support needed to continue home care in the community (2): Creating a Scale of Difficulty in Continuing Home Care

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OBJECTIVES: Home care is medical care provided at the patient's "place of residence" to support individuals needing care and their families. Therefore, it is necessary to have cooperation among a broad range of professionals extending beyond healthcare workers and to utilize a broad range of social resources. This study aimed to elucidate the difficulties experienced by medical providers when continuing home care.

METHODS:

1. **Participants:** We conducted a questionnaire survey by mail targeting 1,010 staff involved in home care/nursing. The collection rate was 53%. In regards to gender, 99 respondents were men and 441 were women. In regards to age, 61 respondents were in their 20s, 147 in their 30s, 157 in their 40s, 125 in their 50s, and 50 in their 60s.
2. **Survey Contents:** Referencing previous research and opinions of medical staff, we created 24 items to inquire about difficulties experienced when continuing home care and sought responses using a five-point Likert scale, from "not at all difficult" (1 point) to "very difficult" (5 points).
3. **Analysis Method:** IBM SPSS Statistics ver19.0 was used for analysis.
4. **Ethical Considerations:** This study was performed upon receiving approval from the Jin-ai University Ethics Committee.

RESULTS: First, we performed exploratory factor analysis on the 24-item scale of difficulty in home care (maximum-likelihood method, varimax rotation). As a result, three nameable factors were extracted; namely, factor one was a mismatch between intentions and opinions (Cronbach's coefficient alpha: .89), factor two was concern over continue caregiving ($\alpha=.82$), and factor three was anxiety regarding cooperation and coordination (.85). The α coefficient of the entire scale was .89, which is considered to show internal validity.

Next, we investigated whether or not differences could be found by age (20s-30s, 40s, 50s-60s) and gender (male, female) in regards to the entire scale of difficulty in home care and each factor. Results showed only a main effect by gender for the entire scale and factor three, with women experiencing difficulty more easily than men (entire scale: $F(1,534)=7.03$, $p<.01$, factor three: $F(1,534)=8.33$, $p<.01$).

CONCLUSIONS: The 13-item Difficulty in Continuing Home Care Scale is a simple, valid, and reliable tool to assess difficulty for continued home care.

Relationship between Bone Mineral Density and Remaining Teeth and Its Related Physiological Factors in Postmenopausal Women

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Objectives: Osteoporosis is one of the most common metabolic bone diseases in postmenopausal women and its prevalence is increasing relate to rapid ageing process in some country. Some studies proposed the relationship between osteoporosis and oral health. This study investigated the association between bone mineral density (BMD) and remaining teeth and to identify the determinant female-related physiological factors for osteoporosis and remaining teeth among postmenopausal women in Korea.

Methods: A total of 3,992 postmenopausal women aged 50 years old or above were selected from the Fourth and Fifth Korea National Health and Nutrition Examination Survey, which were held from 2008 to 2011. Bone mineral density and remaining teeth were assessed by trained researchers. Socioeconomic characteristics and female-related physiological factors such as menarche age, duration of menopause, number of pregnancies, childbearing age, duration of taking oral contraceptives and female hormones were surveyed.

Results: Participants who had lower BMD showed fewer remaining teeth significantly ($p<0.0001$). Out of female-related physiological factors, duration of menopause showed significantly strong relationship to both BMD and remaining teeth ($p<0.0001$). In multiple regression analysis, age, income, education level, BMI, duration of menopause, childbearing age, and duration of taking female hormone drugs were related to remaining teeth.

Conclusions: It was observed that postmenopausal women with osteoporosis had significantly low number of remaining teeth compared to that of normal women. Therefore, we conclude that special care is suggested to promote oral health of postmenopausal women.



Section II

Ragusa SHWA - Book of Abstracts

Editors: Failla S. and Conti A.



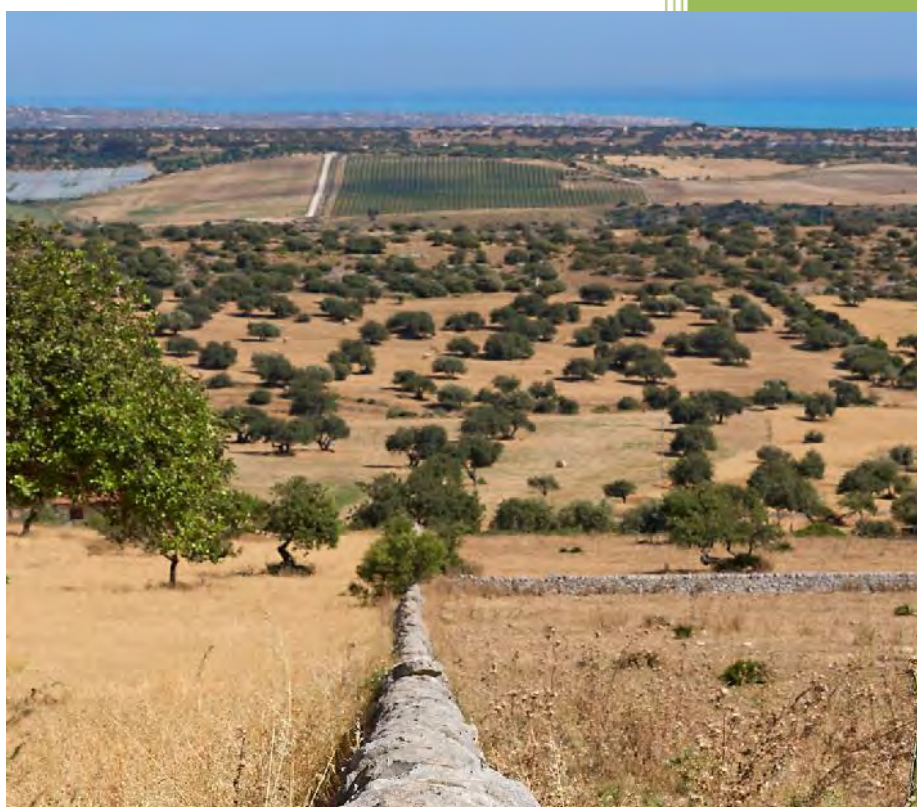
Di3A INAIL
Dipartimento di Agricoltura,
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BOOK OF ABSTRACT

IV International Conference RAGUSA SHWA

“Safety Health Welfare in Agriculture Agro – food and Forestry Systems”



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TOPIC 1

“WMSDs”

ORAL PRESENTATION

Agricultural Ergonomics Research and Outreach in California

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The main aim of this paper is to give an overview of agricultural ergonomics research and outreach activities in California. Another aim is to introduce the California AgrAbility Program.

A discussion about research publications on agricultural ergonomics is presented. In most countries, agriculture is recognized as one of the most hazardous industries, with musculoskeletal disorders (MSDs) being at the top of problems facing workers in labor-intensive agriculture. This talk gives an overview of the extent of MSDs in California agriculture, and a historical perspective on how ergonomics has been used to reduce the health effects of labor-intensive agriculture in California. The California AgrAbility Program is introduced and its main mission highlighted.

A summary of exposure to MSD physical risk factors within various classes of California crops is given. There are various administrative and engineering controls for abating MSDs in agriculture. These range from programmed rest breaks to mechanized or partially-mechanized operations. Worker-based approaches such as prone carts and platforms, and load transfer devices hold promise in combating the prevalent stooped work in agriculture. Although physical risk factors are major contributors to MSDs in agriculture, other psychosocial, organizational, cultural, and socio-economic factors could be important contributors to the development and prevention of these disorders. These factors may play a central role in the effective implementation and adoption of any intervention approach. Despite the advent progress in new technologies in agricultural practices, reliance on labor will always be a major cornerstone of agriculture for at least the foreseen future. An overview is given on how AgrAbility Programs in California and other US states have been assisting disable farmers and farm workers find solutions and other assistive technologies to maintain an active and productive work in agriculture.

Keywords: MSDs, Ergonomics, AgrAbility, Labor-Intensive Agriculture.

OWAS and REBA for the assessment of WMSDs in motor manual tree felling. Which is the best approach?

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The risk to run into a Work-Related Musculoskeletal Disorder (WMSD) is very high when operating in the primary sector. As a matter of fact the number of professional illnesses related to the WMSD in Italy is high.

The study was carried out in the Autonomous Province of Bolzano (northeast of Italy), it consisted in the assessment of operator's postures during felling operations, through the assignment of a WMSD's index of exposure. This assessment was carried out with two different procedures: REBA and OWAS. A comparison of the results obtained from the two assessment tools was performed. In order to perform the assessment, every felling operation has been recorded with a digital camera, and it has been divided into three subtasks: pre-cutting operations, cutting operations and post-cutting operations. For each of them a frame capture every 10 second has been analysed.

The assessment of the OWAS and REBA's score shows that the OWAS standard has a general tendency to assign a lower index to exposure in comparison to REBA. This is evident both for subtask operations and for the whole felling operation. Moreover, OWAS, due to its easier technique for the assessment has shown a greater capability to assess body posture also in not clear situation because the operator was partially hide by a tree or far from the camera.

In conclusion, from this study it is possible to determine that OWAS assessment is able to perform a faster and more precise and sensitive assessment than REBA.

Keywords: Body Posture Assessment, Forestry, Chainsaw, Cutting Operations.

TOPIC 1

“WMSDs”

POSTER PRESENTATION

Study of posture during plowing operations. Analysis of the pressures to the seat.

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With reference to the suspension system, the seats on the market are at the moment basically divided into three groups: mechanical, pneumatic suspended and active/semiactive seats. Since the end of the '60 studies on operator comfort to the tractor showed that the operation of the suspension of the seat is influenced not only by the design of the same, but also by the posture and dynamic behaviour of the driver. Many studies have been developed on the characterization of the stresses for the operator evaluating vibrations in different conditions, in agreement with the European Directives for the approval of seats. Interviews were conducted in the industry, which showed limb disorders whose cause could be related to the pressure against the seat.

It will be studied the interaction between the body and the seat of two operators recording the pressure values of 31 points in which were placed pressure sensors having a diameter of 100 mm². The recording of the data will be during the operations of plowing a field previously planted with corn. It will be recorded the pressure values in the two directions of plowing, alternately with the right and left wheel within the groove.

Processing of the data will allow the evaluation of the effect of stress on the seat to the two operators during plowing operations. Through geostatistical analysis will be realized a map could shows the barometric distribution of peaks. These maps could suggest the critical areas in which the body of the operator is affected by the higher stresses. The preparation of such maps, suggesting the critical areas in which the body undergoes the greatest stresses, can be a step for integration to the reading of the vibrations in the objective evaluation of the comfort of the seat.

Keywords: Comfort, Barometric maps, Agricultural tractor.

A review of recent studies on the risk assessment from repetitive movements in agriculture

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Abstract

Some studies carried out from the AA. in the last years and concerning Work related Musculoskeletal Disorders (WMSDs) in agriculture come are presented.

The studies involve viticulture, tomato growing, nurseries in greenhouses, She – ass milking. In particular, some of them are related to the frequency concerning manual operations, the strength concerning the various part of the hand measured by instrumented scissors specifically assembled.

Results show that for the assessment of the risk should be considered throughout the annual cycle. Instrumented scissors allow to recognize the strength exerted on different parts of the hand. The strength intensity reported by the instrument was correlated to the strength evaluation coming from a group of people and when necessary it can be converted in the Borg CR10 scale normally used for these kind of researches. Physicians could now utilize the measured strength intensity exerted in different parts of the hand with the aim to foresee the development of disabilities involving workers' arm and hand. Results obtained from surveys on vine cutting frequency suggest that the daily curve that represents the cuts per min has to be identify correctly, otherwise the risk could be wrongly evaluated. Obtained results highlight how is important a multi-disciplinary approach, putting together the competences coming from agricultural mechanization (that includes work organization), ergonomics and occupational medicine.

TOPIC 2

“Machine Milking, Animal Welfare, Sustainable Livestock”

ORAL PRESENTATION

Ergonomic issues and musculoskeletal disorders among ewe dairy workers involved in mechanical milking

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In comparison to the traditional practice of hand milking, the use of mechanical milking equipment has considerably improved worker comfort and work efficiency of milking operations on sheep farms. Nearly 50% of Italian dairy sheep are located on the island of Sardinia, where 3.2 million head are raised on approximately 12,700 farms. Over the past 20 years, the industrialization of sheep husbandry has led to a marked increase in average herd size per farm (from 121 to 250 head) and to a large increase in milking mechanization.

Milking operations are mainly performed in parlor milking systems (82% of farms, average 275 head/farm), while bucket and trolley systems are used in small herds with less than 190 head. The parlor design is usually parallel based on a single or double stanchion row mounted along a milking pit where the worker operates. As an alternative, the stalls can be assembled on an elevated platform, either static or movable, thus enabling the worker to operate at the same level of the parlor. Among the low milking systems, the parlor type with 24 stalls and 12 milking units (2 stalls/unit) is the most common configuration, while the type with 24 stalls and 6 milking units (4 stalls/unit) is the prevalent choice in high milking installations. Considering the short milk emission period of the Sardinian ewe, one operator can usually manage about 6-8 milking units without incurring the risk of udder overmilking.

Although mechanization has reduced the physical load imposed on the workers, some studies have reported an association between the cow milking tasks and symptoms of musculoskeletal disorders (MSD) in the upper extremities and back (Nevala-Puranen et al., 1996; Stal et al. 2001; Doupchrade et al., 2009; Kolstrup et al. 2012). Several studies suggest that MSD risk factors are mainly associated to the physical work environment in relation to the worker's anthropometrics (Stal et al. 2003; Jakob et al. 2012; Cokburn et al., 2015). Most of the scientific literature refers to dairy cow milking operations, while only limited information is available on ergonomics of sheep milking parlor systems (Pazzona, 1985; Billon, 2005; Berger 2001). The purpose of our study was to investigate the ergonomic design of ewe milking parlors and the prevalence of MSD symptoms among ewe dairy workers.

Manually Milking Ewes and the Risk of Carpal Tunnel Syndrome

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The region of Sardinia, Italy is known internationally for the production of cheeses made from ewe's milk. Although most developed countries utilize automated milking equipment in ewe and cow dairies, the ancient task of manual milking is still performed in some countries and geographical locations (Kouyoumdjian and Machado de Araujo, 2006; Kutluhan et al., 2009). In Sardinia, Italy, manual milking of ewes is still performed on approximately 50% of ewe dairy farms. Both economic and cultural constraints have limited the adoption of modern dairy equipment by Sardinian ewe farmers. Automated milking equipment has been installed in 5,800 of the nearly 12,800 Sardinian ewe dairies. However, it is estimated that only 5,000 of the milking machines are currently in use. The under utilization of automated milking equipment is primarily due the raise in milk production costs, which has driven the smaller farms to reduce energy and material expenditures. Additionally, ewe farmers have had to increase their flock size to stay competitive. Larger flocks result in longer periods of manual (hand) milking (Figures 1 & 2). Manual milking is a task that has been characterized as “a natural model for occupational carpal tunnel syndrome (CTS)” (Kouyoumdjian and Machado de Araujo, 2006). The purpose of this descriptive study was to evaluate the prevalence of CTS among Italian ewe farmers that manually milk sheep and compare them to a sample of cow dairy farmers that use mechanical milking equipment.

TOPIC 3

“Instrumentation, Equipment, Periodic Procedures and Tests”

POSTER PRESENTATION

A laboratory test bench to analyse nozzle sprays

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Aim of this study is to propose a low cost laboratory test bench, suitably designed to analyse nozzle sprays according to the procedure described in ISO 5682-1. It consists of a transportable trolley carrying a tank, a two diaphragms pump driven by an electric motor, and a spray boom carrying one multiple nozzle holder. The spray boom may move, under the control of a DC motor, along two slides placed above the working plane of the trolley. Acceleration and deceleration ramps may be imposed by the speed controller. According to the procedure described in ISO 5682-1, the test liquid is sprayed above Petri dishes placed on the working plane and containing silicon oil: analysing the images of the drops captured inside the oil, it is possible to measure the spray drop diameters and then all the spray features. The image acquisition system is under development.

Moreover, the test bench will be used to correlate spray features to water sensitive paper (WSP) images. Spraying at the same time Petri dishes and WSPs, the image of drops inside Petri dishes will be correlated to images on WSPs, so allowing the calculation of unitary deposits from WSP.

Finally, the tests bench will be used to experimentally validate a model describing the WSP behaviour when sprayed with drops of assigned drop size distribution and volume median diameter. In this paper WSP images were produced by simulation, assuming some simplifying hypotheses: spherical drops and circular stains randomly placed on the images. Three types of spray were simulated (Fine, Medium and Coarse) with two drop size distributions (log-normal and Rosin-Rammler). The simulations showed that the unitary deposit can be derived from the measured percentage of covered surface on the WSP images, but the knowledge of the volume median diameter of the drops is necessary, independently of the probability distribution function of drop size.

Keywords: Pesticide Application, Image Analysis, Drop Pulverisation.

Evaluation of pump-over thermal effect during red grapes fermentation: preliminary results

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In oenology, pump-over is a mechanical technique used to enhance the fermentative maceration. Pump-overs are conducted, with or without air contact, by taking the must from the bottom of the fermentation tank, and using it to spray the cap. The aim of this practice is the enhancing the phenolic and volatile compounds extraction from grape skins. Consequently, wine quality is improved in this way.

During some temperature monitoring tests a “secondary” effect of pump-over has been highlighted. Temperature affects volatile and phenolic compounds concentration too. Particularly, low temperatures may be used to improve volatile production by yeasts during fermentation, and regulate the extraction of polyphenols compounds from the solid to the liquid phase.

The aim of the work is to describe the thermal effect of pump-overs with and without air contact during a red fermentation.

Tests have been performed during the September 2014 Tenuta Argentiera (Bolgheri (LI), Italy) in a tank of 20 m³ capacity. Six probes were placed into the fermentation tank, for temperature monitoring in different zones during pump-overs.

Both kinds of pump-overs produce two main effects during fermentation: a temperature homogenization, reducing the differences among the zones of the tank, and a cooling effect, reducing the average temperature of the must. Hence, in addition to their effect on compounds extraction, pump-overs could be useful to reduce and control the temperature during red fermentation.

Keywords: Quality, Temperature, Wine.

Hose reel vs dripline irrigation systems: which is better from Carbon Footprint standpoint?

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Irrigation plays an essential role in the cultivation of crops but it also has a relevant contribution to the environmental impact of agriculture. The present work analyzes the Life Cycle of hose reel and dripline irrigation systems, with the aim of evaluating and comparing their carbon footprint. LC analysis was carried out using the software Simapro, with the support of the Ecoinvent Database. Although water consumption is the main indicator used to assess efficiency of irrigation, it is not sufficient to evaluate its overall sustainability. Indeed the use of irrigation equipment and machines cause a large amount of GHG. The GHG of the irrigation systems have been assessed by analyzing two stages of their life cycle: production and use phases. Production phase encompasses all the impacts due to the machine industrial manufacturing from raw material extraction and processing, to production and assembly of the various components. Use phase considers the impact due to energy consumption for water distribution to the field. The functional unit is the m³ of water distributed under average technical and climatic conditions of central and northern Italy. Results show that dripline systems give rise to the highest GWP. Their high impact is due to their short lifetime, since they have to be replaced annually. On the other side, the lifetime of the travelling rain gun span for over 15 years and therefore their production impact has a lower contribution able to compensate the higher impact of the use phase due the high water working pressures.

Keywords: Irrigation, Carbon Footprint, LCA.

An olive pruning machine for marginal areas

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In many sub-Apennine areas of central Italy, climatic and soil difficulties caused the spread of the olive trees more than other crops, thanks to their ability to adapt to those conditions and thanks to the help of dry stone walls.

In this way in the past was possible to have many olive lands, today in those lands there are marginal olive groves. In fact in such areas, the maintenance of olive groves is expensive and difficult, especially regarding the practice of pruning. In the absence of such pruning, olive trees would return to being new woodland. Pruning also requires workers with specific skills to maintain the right shape of trees. Such labor is increasingly unavailable.

Due to the large gradients, which make difficult and dangerous the machines use, subject to instability and tipping, with consequent risks for the operator, the mechanization is not able to improve the situation totally. In fact in many areas olive groves are neglected, resulting no gains for the farms and also lack of those areas maintenance. It is also necessary to consider the known environmental hazards related.

The aim of the research is to assemble a new machine with pruning bar provided with rotary discs, and totally operated by a remote control. The driver is placed on the ground some meters far from the machine to reduce the risk to his life, in the case of the machine rolling over.

To evaluate the efficiency of the machine some pruning tests will be done in marginal areas.

Keywords: Pruning Machine, Steep Ground, Remote Control.

TOPIC 4

“Noise, Vibration, Dust, Endotoxin, Microorganism”

ORAL PRESENTATION

Field and static tests to assess the drift of abrasion dust of dressed maize seeds

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Pneumatic precision drills employed in maize (*Zea mays* L.) sowing are responsible for the emission in the atmosphere of abrasion dust containing active ingredient (a.i). In recent years, several insecticides (especially neonicotinoids) employed for maize seed dressing have been claimed to cause mortality and sub-lethal effects to honey bee (*Apis mellifera* L.). Moreover, the emitted particulate matter can be inhaled by the operators during the seed loading and manipulation and during the sowing. This work aims at assessing the amounts of a.i. emitted by precision drills during sowing operations. We carried out static tests, simulating the sowing at fixed point, and real sowings in field. To collect a.i. residues, we used passive samplers (Petri dishes) for the residues at ground level. We employed maize seeds treated with three neonicotinoids insecticides (clothianidin, imidacloprid and thiamethoxam) and with fipronil. The results show the amounts of dust emitted by a pneumatic precision drill during the sowing of maize. Moreover, a method to predict the theoretical dust drift in the field, starting from the results of the static test, is provided.

Keywords: Pesticides, Airborne Particulate, Neonicotinoids, Honey Bee, Seed Coating.

Whole-Body Vibration exposure.

An ergonomic evaluation of the effects of an active suspended cab fitted on an agricultural telehandler.

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Exposure to whole body vibration (WBV) is one of the most important risk factors for musculoskeletal disorders (MSDs). Agricultural machinery operators are particularly at risk and it is therefore important to minimize the transmission of harmful vibrations to the driver as much as possible. Telescopic handlers are self-propelled vehicles very versatile used on different terrains and for different operations. Despite their diffusion few studies investigated their vibrational safety and comfort. The objective of the study was to investigate whether an active cab suspension system fitted on a telehandler was effective in reducing WBV and in improving comfort. Sixteen male healthy professional operators drove a telehandler on a 100m ISO 5008 smooth track at two different speeds (5 and 12 kph) with activated and deactivated cab suspension system. Adopting an ergonomic approach, different aspects of the human-machine interaction were analyzed: 1) WBV measurements, 2) subjective ratings of general comfort and local body discomfort, and 3) anthropometric characteristics of the users. The suspension system was effective in reducing WBV and in improving comfort, especially for individuals with higher stature, body mass and Body Mass Index (BMI). Some neck/shoulder and lumbar complaints seem to remain, even when the system was activated. Results suggest that the operators, given their wide range of physical variability, may need more adjustable or customizable WBV reduction systems.

Keywords: Ergonomics, Comfort, WBV, Telehandler, ISO 5008.

A filtering-recycling device to reduce dust drift from pneumatic drills

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The utilization of dressed seed is a widespread practice to control pests and diseases with reduced doses of pesticides. In recent years, some insecticides employed in seed dressing (namely neonicotinoids and fipronil), have been claimed to contribute to honeybees (*Apis mellifera* L.) spring mortality and decline. Pneumatic precision drills used in maize (*Zea mays* L.) sowing can release amounts of dust coming from the abrasion of dressed seed. To reduce dust spread, we developed an effective prototype device for pneumatic drills, which uses partial recirculation and filtration of the air by means of an anti-pollen filter and an electrostatic filter. Tests at fixed point (simulating sowing of maize seed treated with imidacloprid, thiamethoxam, clothianidin and fipronil) were carried out to assess the efficiency of prototype. Measurements were carried out by sampling, with different methods, the air emitted by the drill in different configurations. With the application of the prototype having the double filtration (anti-pollen plus electrostatic filters), gravimetric and chemical analyses of samples showed values of reduction of emissions always greater than 90%, both in terms of the total mass dust and of the a.i. The application of the electrostatic filter to the system resulted particularly efficient in the reduction of the smaller particles (up 4 µm of diameter). The contribution to the reduction of the sole recirculation system was around 70%. This study contributed to the description of abrasion dust in terms of particle size distribution and provided elements which are useful to further development of the prototype.

Keywords: Neonicotinoids, Honeybee, Seed Coating, Particulate, Aerosol, Pesticides.

Model to analyse semi-active suspension system for a tractor cab

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Tractor driving causes comfort and spinal problems due to low-frequency vibrations. For these reasons suspension systems have been adopted in order to limit the vibration transmitted to the driver. However, it has been shown that despite the use of traditional devices like suspensions on the axles, on the cab and on the seat, the level of vibration in some operations is higher than the vibration level limit prescribed by the Directive 2002/44 /CE. The vibration may be reduced through semi-active cab suspension system. The purpose of this research is to develop a specific control system for tractor cab semi-active suspensions in order to reduce the level of vibration compared to traditional suspensions. The analysis of the results shows that the designed control produced a reduction in the level of vibrations transmitted to the driver and an increase in the driving comfort.

Keywords: Ride Vibration, Agricultural Machinery, Controlled System.

TOPIC 4

“Noise, Vibration, Dust, Endotoxin, Microorganism”

POSTER PRESENTATION

Development of an app for using a smartphone as vibro-meter for effects on health evaluation

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Italian statistics on work safety are pointing out an increasing number of reports about professional diseases. In this frame are considered the whole-body vibrations (WBV) that could affect operators driving agricultural tractors. The common approach to prevent the related pathologies is to measure some situation that could be representative of the task or to refer to existing database with similar tractor and use. This research follows the approach of monitoring in real time and providing for the development during the working day the driver's level of exposure with a vibro-meter developed as an app to be used with a common smartphone.

This application respects the filters and the weights reported on the ISO 2631:1997; the smartphone has an orientation to respect and gives on the three axis the real time data of exposure (the last minute), the daily exposure (referred to 8 eight hours of work) and the time of exposure. The application has been tested on an agricultural tractor in different operative conditions.

The application provides a simple method for an initial assessment of whole body vibration level of exposure. The system can't substitute a certified chain of measurement but could represent a low-cost device for operator's training for practically explaining the question of the dose of vibration and the importance of monitoring the daily, cumulative dose of vibration.

Keywords: Tractor, Safety, Whole Body Vibration, Early Warning.

Noise, vibration and dust emissions of a forestry chipper

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Wood biomass is an important energy source, which is attracting much interest from research and agro-industry. Before energy conversion, wood biomass is generally processed into particles of variable size and shape. This treatment is called chipping and it is performed by chippers. Chipping operations generate much noise, vibration and inhalable dust, which can cause potential health risks for the operators. We tested a chipper (Farmi CH260) with loader feeding for chipping of wood material until 260 mm of diameter, powered by a four wheel driven tractor. The tests of chipping were conducted on seven years old poplar trees. The noise and vibration levels were measured in accordance with the ISO 1999:2013 and the ISO 2631-1:2014 standards. The amount of inhalable dust, during field operations, was evaluated according to UNI EN 481:1994. In line with the requests of the Italian law no. 81/2008 and the measured values of noise and dust emitted and vibration transmitted, we calculated the personal daily exposition to noise, vibration and inhalable dust levels, in terms of $L_{EX,8h}$, $A(8)$ and $mg\ m^{-3}$, respectively, with the aim to evaluate the most risky parameters of the wood chipping operations.

Keywords: Wood Comminution, Operator Seat, Poplar, Whole-Body Vibrations, Exposure Time, Health Protection.

Laboratory vibration measurement from hand-held harvesters for olives

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Vibration represents the most important risk connected with the use of portable harvesters for olive and other drupe. This research was developed within an inter-laboratory test (Round Robin Test – RRT) with the purpose of measuring the vibration to the hand-arm system produced by one portable harvester. To standardise the measurement under load conditions, a suitable laboratory test bench was used. This paper reports the results obtained by the Section of Mechanic and Mechanisation of the Di3A.

The results showed an average acceleration of 2.6 m s^{-2} in idling running and of 13.6 m s^{-2} under load conditions. The highest component was always along x direction (12.8 m s^{-2} under load), the lowest in y direction (1.8 m s^{-2} under load). The test bench proved to be a useful tool to standardise the test conditions, but further studies are necessary to compare acceleration values measured with the test bench and during harvesting.

Keywords: Safety, Olive Harvesting, Vibration Exposure, Hand-Arm System.

Dust emissions with a new hazelnut mechanical harvesting prototype

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The mechanical harvesting of hazelnuts (*Corylus avellana* L.) can show a potential health risk because machinery raise soil particles and dust that can be inhaled by the operators. The paper points out the possibility of reducing the quantity of respirable dust emitted into the atmosphere during the harvesting operations by the use of a prototype pick-up harvesting device, mounted on a self-propelled vacuum machine. The tests were carried out in September 2014, to determine the amount of dust emitted into the atmosphere during the hazelnut harvesting. The tests compared the performance of the machine with the novel device mounted and the same model of the vacuum harvesting machine equipped with the conventional harvesting system (consisting of two counter-rotating brushes with rubber blades). A portable particle laser spectrometer and a personal air sampler with a membrane filter were employed to measure the respirable particulate. In average, a lower concentration of dust was recorded near the operator who drives the harvesting machine, with some differences depending on the employed system (spectrometer or air sampler) to assess the dust concentration. The reduction of dust emission is likely due to the configurations of the novel device, which can contain the dust emitted during the harvesting. Further research will be conducted including the determination of the level of free crystalline silica (SLC), another risk factor for the health of operators.

Keywords: Health, Comfort, Particulate Matter, *Corylus avellana* L., Harvesting.

Risk of exposure to fluoro-edenite fibers of agricultural workers operating in Biancavilla's territory

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The municipality of Biancavilla lies 515 m above sea level on the SW slope of the Etna volcano in Sicily, Italy. It extends for about 70 km² from Mt Etna to the river Simeto and the town occupies a twentieth of its territory. The economy of the city is mainly based on agricultural, sheep and cattle breeding and meat and dairy products.

A significantly increased standardised rate of mortality from pleural mesothelioma recorded among its inhabitants is comparable to that reported in asbestos-exposed cohorts (Di Paola et al., 1996). This mortality rate has been attributed to exposure to a fibrous amphibole identified by Gianfagna and Oberti (2001) as fluoro-edenite (FE), chemically similar to tremolite except that its OH groups are replaced by fluorine. FE fibres have been found in inert materials, such as sand and rubble, extracted from a stone quarry excavated inside the Mt Calvario, lying on the immediate outskirts SE of the town. This material has been widely used for about 50 years for local building (Comba et al., 2003; Paoletti et al., 2000; Rapisarda et al., 2003).

FE has been recently classified by the IARC as carcinogenic to humans (Grosse et al., 2014).

In a previous study we identified a high risk of pleural plaques in building workers occupationally exposed to FE (Rapisarda et al., 2015).

In the present study, in order to assess the concentration and diffusion of airborne FE fibres in the farmland around the municipal territory, we have used a previously validated sheep model (Rapisarda et al., 2005), as a biological indicator of fibre pollution. In this way it is possible to assess the risk of exposure to FE fibers run by agricultural workers.

Noise risk assessment in a modern oil mill plant

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High levels of noise usually occur in the oil mill plant because of the machines used to extract extra virgin olive oil. In Italy the Law Decree 81/2008 defined the requirements for assessing and managing noise risk, identifying a number of procedures to be adopted at different noise levels to limit workers exposure. This study aims at evaluating the equivalent and peak noise level inside a modern oil mill plant area. Twenty measurement points were identified inside the oil mill plant area where the machines for olive oil extraction are located (about 200 m²). The instrument used for the measurements was a precision integrating portable sound level meter, class 1, model HD2110L by Delta OHM, Italy. The measured sound levels exceeded the limits allowed by the regulations in all the measurement points inside the working area; values exceeding the threshold limit of 80 dB(A) were recorded coming up to a maximum value of 93.3 dB(A) close to the hammer crusher. The operators involved are obliged to wear the appropriate Personal Protective Equipment.

Keywords: Noise Risk, Oil Mill Plant, Threshold Limit.

TOPIC 5

“Occupational Health”

ORAL PRESENTATION

Safe in the field: a project for training and integration of foreign agricultural workers

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The project "Safe in the Field", funded by the Lazio Region and activated by Department of Science and Technology for Agriculture, Forestry, Nature and Energy and "Innovation & Resources" Ltd, was launched September 15, 2014 and ended March 14, 2015.

The first phase of the project was a research regarding the training needs for workers in the farms of Lazio Region. Subsequently training courses were provided, each lasting 10 hours, per groups of workers from different nations (Italy, India, Romania), with the presence of native tutors in the classroom and the availability of educational materials in language.

One of the aims of the research is to understand the relationship between risk perception among farmers and the main risk factors to which they are exposed. Furthermore to investigate the influence of the training in risk perception in agriculture.

The research regarding the training needs for workers was done by means of a study on distribution of different crops in the region, a study on injuries and occupational diseases in agriculture (Lazio) and a questionnaire submitted to a sample of farms.

As it regards the research on risk perception, the data collection was made possible thanks to the use of a questionnaire designed to investigate the perception of risk that was given to a sample of 99 agricultural workers at the beginning and at the end of the courses.

The results of the project consist in training of agricultural workers. A product of the project was the site <http://ergolab.wix.com/sicurincampo> that provides a platform for the support of teaching materials for work health and safety training for farmers (training materials in 5 languages).

A previous research from the same Authors showed that the perception of risk is related to having attended training courses, but those who report having attended safety courses do not always enact safe behavior.

While we cannot draw conclusions about the behavior of workers after attending the course, the analysis of the questionnaires shows a clear improvement in the perception of risk.

Keywords: Training and Information, Foreign Workers, Safety and Health.

Injuries for female workers in agriculture – An initial study on causes and preventive measures

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The aim of this paper was to contribute to the future prevention of women's occupational injuries in agriculture via identifying the main causes and circumstances related to these injuries.

The study included analyses of existing data of occupational injuries during a five year period (2009-2013) suffered by women working in agriculture in Sweden. The injury data consisted of compensated work injury claims from the AFA Insurance and work injuries reported to the Swedish Work Environment Authority. Descriptions of the specific events of about 600 injury claims and reports were studied thoroughly in order to gain a deeper understanding of the causes and circumstances. The data regarding, for instance, the source of injury, age, time of year, type of production, injury characteristics and other factors, were analysed. Based on the statistical output, the causes and possible preventive measures were discussed with a reference group consisting of people with extensive practical experience in the area of agriculture work environment.

Preliminary findings indicated that the majority of injuries were animal-related (~55 % of the injuries), with cattle as the most commonly involved animal followed by horses. Cases associated with sorting/moving cattle, leading horse and milking tasks represented high proportions of the injuries. Working with livestock were subjects to the injury in 64 % of the cases, and younger women (<25 years) seemed to be overrepresented in the statistics. The injuries occurred more frequently in the months of September and December.

The further analysis of the injuries should be carried out as a case study together with the suffered persons in the field to gain more detailed information of the underlying causes and suggest more specific measures. The focused areas of preventive measures were also discussed.

Keywords: Prevention, Risk, Work-Related Injury, Statistics, Animal.

Psychosocial condition and mental health of Swedish farmers and rural entrepreneurs

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The expansion of small family farms often implies increased financial responsibility, risk taking, employer responsibility and long working hours. Agriculture represents a profession whose success is highly dependent on uncontrollable external conditions such as weather, legislation, disease outbreak, environmental changes and negative societal attitudes. Moreover, farmers' face normative and market pressures and are expected to maintain high production standards, a stable economy and to act in socially conscious and environmentally responsible ways. The combination of uncontrollable external factors, increased expectations and weak social support may cause poor psychosocial working conditions and ultimately a decreased mental health.

The objective of this study was to examine the psychosocial working conditions and mental health of farmers' operating small size Swedish farms with different production sectors such as crop, dairy, beef and pig.

The study was conducted in 2010-2011 among 470 farmers comprising 177 crop farmers, 139 dairy and beef farmers and 154 pig farmers. The General Nordic Questionnaire for Psychological and Social Factors at Work (QPSNordic) was administered to assess subjective perceptions of the psychosocial work conditions and mental health.

The three groups reported general well-being regarding their psychosocial work conditions and health, however, dairy and beef farmers perceived their psychosocial work conditions and mental health as worse compared to crop and pig farmers. This was characterized by higher work demand, more negative impact regarding work and leisure time, less contentment concerning how the dairy and beef farmers dealt with the physical and psychosocial work demands, worse general health and more exhaustion after a work day. The participants were asked about the extent to which they felt stressed by various external factors. The external factors that especially crop farmers and dairy and beef farmers experienced as most stressful was the EU legislation, comprehensive subsidy regulations, lots of governmental and EU-related controls and delayed payments, and the Swedish authorities' attitude towards farmers. Increased demands on environmental issues, from society and consumers, weather conditions, animal welfare legislation, varying market prices, increased crime in rural areas, agro-terrorism, disease outbreaks among plants and animals and concerns for the future of the farm were other external factors that were stressful for the farmers. Based on the results, an action plan for improvement of the psychosocial working conditions, mental health, and social support in rural areas should be the next step to be developed.

Sustainable health and safety of Ugandan farmers

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‘Sustainable agriculture’ and food security requires ‘sustainable health’ and safe working conditions for farmers and farm families. Farmers in good health will be able to provide for their families and contribute to the local farm community. There is limited or almost non-existing research available regarding health and safety of farmers in Africa and data is essential to understand and change patterns of human health and safety. In Uganda, these issues are not considered from an agricultural aspect although the majority of risk factors regarding human health and safety are related to agriculture.

The objective of the study was to interview Ugandan farmers and family members regarding their attitudes towards health, safety and risk factors in an agricultural context, and how it affected their daily lives and livelihood.

The study was conducted in Uganda May 2014 and comprised interviews with seven male and female farmers, and transects walks on each farm.

In general the level of knowledge and awareness of agricultural health and safety risks, disease and injury prevention among the farmers was low. The farmers claimed few agricultural related complaints, injuries or diseases. It was obvious from the farmers’ responses that health and safety concerns (e.g. diarrhea, cough, fever), cuts while using the machete in the plantation, bruises when handling the animals and symptoms of poisoning from using insecticides on the

animals were nothing worth talking about and considered as part of the occupational hazard. The most important topic mentioned by the farmers was the use of chemicals and drugs related to livestock. Once a week the farmers sprayed the animals with an insecticide to prevent ticks, lice, tsetse flies and other biting nuisance flies using a back or hand sprayer. The spraying was conducted without personal protection equipment (PPE) which was considered too expensive and difficult to obtain. The farmers explained that they usually felt unwell, dizzy, vomited, and had pain and burning feeling in the face and eyes after spraying. Sometimes the symptoms were so severe that they needed treatment and bought medication without prescription at the local drugstore where the storekeeper often had limited or non-existing knowledge about the chemicals or drugs, except for dosage.

The availability of agricultural health and safety training in the region was non-existing and the farmers expressed the need for information and practical training in agricultural health and safety, disease and injury prevention.

Health and Safety Challenges among Dairy Workers in the United States

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Dairy farming is among the most dangerous agricultural settings. The purpose of this study was to describe the work experiences of dairy workers in the United States (U.S.) to design appropriate safety training programs. The long-term goal of the work is to eliminate occupational injuries among a vulnerable (primarily Latino) workforce in industrialized dairy operations.

Focus groups were conducted before or after work shifts. Workers were asked to describe their work experience at the dairy, quality of relationships with their coworkers and manager/s, as well as safety policies and procedures, and training experiences. Focus groups were conducted in Spanish and required approximately one-hour. Discussions were recorded, transcribed and translated into English, and analyzed for themes. Forty-four dairy workers participated.

The workers described their jobs as highly stressful, characterized by strenuous manual labor and time pressures. Participants reported many equipment issues and environmental hazards on the dairy, including exposure to unsafe conditions and numerous harmful substances. Relationships with coworkers were generally described as positive and team-oriented, while relationships with managers were more varied and negative. Participants reported limited knowledge regarding safety policies and procedures and made numerous suggestions for how to improve safety training.

The participants identified individual, organizational and environmental points of intervention that can be used to inform management and training programs in order to promote and maintain a higher level of safety within the U.S. dairy industry.

Keywords: Occupational Health, Dairy Workers, United States.

Community Engagement in the Prevention of Injuries and Deaths from Agricultural All-Terrain Vehicle Use

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All-Terrain Vehicles (ATVs) have become an essential aspect of efficient agricultural work but have led to many injuries and deaths. Since 1982 over 12,000 people have been killed in the United States riding ATVs for occupational and recreational uses (CPSC, 2014). ATVs are used in farm and ranch operations with increasing popularity resulting in 65% of all occupational related deaths occurring in the agricultural sector (Helmkamp et al., 2012). Occupational use of ATVs (Figure 1) is on the rise in many sectors because of their versatility, adaptability and affordability but has led to a nearly 200% increase in work-related fatalities reported in the U.S. between 1999 and 2008 (Helmkamp, 2011).

TOPIC 5

“Occupational Health”

POSTER PRESENTATION

Evaluation of safety aspects on a machine for nuts harvesting

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The great part of the machine on the market for the collection of the nuts is characterized by a suction member placed over a cart with wheels or tracks, pulled by a tractor. This solution, although effective and efficient in rational cultivation with planting distances designed specifically to allow the passage of agricultural vehicles, misses instead possibility of use in spontaneous mountain hazel, without a regular planting distance. Moreover, the steep slopes that usually occur in wild hazel, make impractical the manoeuvres with the possibility of overturning the tractor vehicle and the carried truck.

Recently were born, also in the traditional way, simple mechanical solutions which consist in placing the suction member for harvesting, above small self-propelled trucks. Recent research has been conducted to evaluate the safety of the operations of harvesting of nuts in sloping land related aspects in noise and roll-over.

In this study was evaluated, in addition to efficiency and to working hours, safety aspects of a machine made by a local craftsman, but that has a commercial success in the Etna area, of considerable importance for the Hazelnuts in Sicily and for the Nebrodi park. The machine is characterized by a vacuum system placed on a self-propelled crawler to collect the nuts in sloping land and with soils corrected with very close terraces and not easy to reach for the traditional mechanization. In particular, attention was focused to aspects of noise level and to stability, evaluated by a tiltable platform.

Moreover will be assessed the principle health risks due to biomechanical overload (Work related Skeletal Muscle Disorders), will be analysed through the indices risk assessment of increased use, with particular regard to the operators involved in the harvesting and the manual handling of the product.

Data analysis and evaluation of safety aspects will identify the machine's ability to meet the harvesting operations and any limitations in terms of safety.

Keywords: Safety, Harvesting, Nuts.

Influence of training, procedural and organizational measures in the reduction of the risk due to manual handling of loads

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The link between the musculo skeletal disorders (especially those affecting the bones, nerves, joints, muscles, tendons and blood vessels) and manual handling of loads, is nowadays worldwide recognized. This risk is present in many production sectors, but in some activities more than others, including agriculture (INAIL), risk indexes are often above the warning thresholds.

The research evaluated 20 agricultural and agro-livestock Lazio's farms, using a methodology proposed by EPM Research Unit (Milano, Italy) in compliance with criteria laid down by Annex XXXIII of the Italian Legislative Decree n. 81/2008 (transposition of several European Directives including 90/269/EEC about manual handling of loads).

This research also studied appropriate ways to make a quantification of the efficiency and effectiveness made by the procedural and organizational redesign proposal, presenting concretely and economically feasible measures, useful in the short term.

Keywords: Niosh, Risk Analysis, Prevention, Safety and Health.

A population-based comparison of injuries among farm and non-farm adults in Alberta, 1999-2010: A retrospective cohort.

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Agriculture is considered as one of the most hazardous occupations with the 4th highest mortality rates by industry in Canada. The purpose of this study was to examine the rates and risks of (1) all-cause and (2) agricultural injury across adult farm and non-farm populations in Alberta.

We conducted a population-based retrospective cohort study utilizing data from multiple administrative health databases. Crude injury rates were calculated and proportional-hazards regression with a counting process was applied to obtain hazard ratios for injury adjusting age and sex.

We identified a total of 220,911 adults who experienced 947,247 injuries. Rural Non-Farmers experienced the highest death rates at 74/100,000 person-years, followed by the Farm Rural study group at 58, the Urban group at 52.1 person-years and the Farm Urban group at 48.1. All cohorts had higher hazards of all-cause injury when compared to the urban cohort after adjusting for age, and sex (Rural Non-Farm Hazard Ratio (HR)=1.09, 95% CI 1.07-1.10; Farm Urban HR=1.09, 95% CI 1.07-1.10; Farm Rural HR=1.08, 95% CI 1.07-1.09). Farmers experienced 87.5% of all agricultural injuries, with the HR= 4.68 (95% CI 4.39 – 4.99) for Farm Rural and HR= 2.87 (95% CI 2.66 -3.11) for Farm Urban when compared to the Rural Non-Farmers and adjusted for age and sex.

This study identified that injury incidence rates, severity and intent varied among urban, farm and rural cohorts. These observations suggest that intervention initiatives, with specific population and mechanism targets, are needed to tackle the challenges of injury prevention in different rural populations.

Keywords: Agriculture, Injury, Health Data, Death

Assistive Technology Database for Farmers and Agricultural Workers with Physical Disabilities

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Purdue University manages the largest known database of assistive technology appropriate for safely enhancing the independence and productivity of farmers and agricultural workers with physical disabilities. The poster will explain the organization structure of the database (www.agrability.org), the contents and how it is used internationally by rehabilitation professionals working with farmers. Data on visits to the site and the most commonly used components will be presented.

Key components of the website relate to both commercially available devices and locally fabricated devices that have been designed to increase the independence of those engaged in production agriculture. The database currently includes over 1,100 items. Additional resources include technical articles on a wide range of barriers faced by persons with disabilities.

Users of the site represent over 20 countries and include primarily rehabilitation professionals and farmers with disabilities. Approximately 5,000 unique visits are made to the site each month.

A survey on occupational injuries in tree climbing in Italy

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The aim of this work is to know how many injuries occur to tree climber arborists, during their pruning and felling work on tall trees, both to know what kind of accidents and the reason why them happens. This study was made by means of "INFORMO", an INAIL's database which contains a list of serious and fatal injuries occurred from 2002 to 2012 counted by INAIL's Prevention Service. From such list Authors extracted only accidents related to operators who was working on tall trees, at least 2 meters above a stable ground, without using lifting platform. In these case operators would have to use ropes and harness. The result of the study consists in understanding common triggers of injuries, knowing if there are technical problems that can be solved, or other problems that can be addressed to decrease the number of accidents and their severity.

Keywords: Arboriculture, Work at Height, Safety and Health.

A Certificate Course for the Agricultural Safety & Health Profession

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In 1996 a Certificate Course in Agricultural Medicine was designed by a multidisciplinary consensus group in the U.S., primarily for health care providers. This course has expanded to 9 states in the U.S., Australia, and Turkey. A similar course for agricultural safety and health professionals has not existed. The objectives of the Agricultural Safety and Health Certificate Course were to: 1) Identify subject matter appropriate as core knowledge for practicing agricultural safety and health professionals; 2) Develop learning objectives for the core subject matter; and 3) Offer a pilot Agricultural Safety and Health Certificate Course.

TOPIC 6

“Environment Safety, People Health Protection and Welfare”

ORAL PRESENTATION

Italian Potential Biogas and Biomethane Production from OFMSW

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This work is aimed at predicting the potential biogas and biomethane production, using the Organic Fraction of Municipal Solid Waste (OFMSW), in Italy, where 1388 Anaerobic Digestion (AD) plants (power of 7.4 TWh, equal to 640.4 ktep) are nowadays available.

In order to compute the potential biogas and biomethane production in the 20 Italian regions, the data about OFMSW production in 2010-2013 period have been evaluated.

The Italian production of OFMSW, that was 5.2 million tons in 2013 (18% of MSW), could be used inside bioreactors for producing biogas and digestate, that must be aerobically composted into a biofertiliser. In 2013, the Italian potential biogas production from OFMSW was 739 million m³, that is equal to 444 million m³ of biomethane. The highest biogas production from OFMSW was in Lombardy region (143 million m³), having a potential biomethane production of 86 million m³. The highest OFMSW production per inhabitant was in Emilia-Romagna region (142 kg). Yet, if OFMSW was 37% of MSW, the potential biogas and biomethane production should be increased: the biomethane production increase would be 486 million m³, of which the maximum would be in Sicily region.

The biogas produced can be used for generating heat and electricity or upgraded into biomethane, distributed at dedicated stations and useful as biofuel for powering means of transport. This biofuel would replace natural gas, and, therefore, allow a reduction of GreenHouse Gas emissions of 200 g of CO₂ kWh⁻¹ (5.5 times lower) and the import of fossil fuels from abroad.

Keywords: Organic Waste, Anaerobic Digestion, Biofuels, Biofertilisers, GreenHouse Gas Emissions.

Summary of U.S. Agricultural Confined Space-Related Injuries and Fatalities and Comparable International Findings

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Purdue University's Agricultural Safety and Health Program has been documenting injuries and fatalities associated with agricultural confined spaces for over 30 years. To date, nearly 1,800 U.S. incidents/cases have been documented and findings entered into a database. In addition, cases outside the U.S. have been documented, but not included in summary data reported to date. Findings from the U.S. cases have been summarized and reported on an annual basis for the past decade. These findings have been used to promote enhanced safety measures designed to reduce the severity and frequency of agricultural confined space-related incidents.

This presentation summarizes all documented incidents including those identified outside the U.S. It is believed, based upon the frequency of non-U.S. incidents, that the problem of worker injuries and fatalities while working inside agricultural confined spaces is an international safety issue. This is especially true for incidents involving the transport, storage, and processing of agricultural grains.

Findings regarding causative factors such as type of grain and structure, worker characteristics, and the role of out-of-condition grain on increased risk of entrapment will be presented. Recommended preventative measures will be discussed.

Keywords: Grain Entrapment, Agricultural Confined Spaces, Grain Engulfment, Toxic Environments.

Determination of bystander exposure to pesticide spray drift: methodology proposal

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The potential spray drift exposure of bystander and residents from orchard pesticide applications is likely to be higher than from boom sprayers, especially in Italy where the close interconnection between urban and rural areas amplify this phenomenon. On request of European Commission the European Food Safety Authority (EFSA) established a working group (WoG) for revising all available data and procedures to perform the operator, worker, resident and bystander pesticide risk assessment (EFSA, 2014). For orchard crops and vines, the most used dataset is Lloyd et al. (1987). The WoG recommended that further data shall be produced to refine the proposed assessment. Besides having limited data available at present there is no standardized method for collecting data on resident and bystander pesticide contamination. The aim of this work was to assess the efficiency of different collectors types and the different test layouts, in order to evaluate the better solution for detecting the pesticide exposure of bystanders during plant protection product (PPP) application and to propose a test methodology that may be combined with the existing ISO22866 standard methodology for arable crop pesticide drift measurement. The proposed methodology has been applied in field experiments undertaken in 2013 and 2014 measuring spray drift deposits on mannequins (coveralls and synthetic filter clothes collectors) and airborne spray drift (Petri dishes, vertical polythene line collectors). The results obtained have underlined a lacking relationship between different type of collectors, underlining the need of an appropriate experimental framework able to define the most suitable collectors type and layout to be used.

Keywords: Pesticide Bystander Exposure, Airborne Spray Drift, Collector Types, Test Methodology.

A survey on work safety in 103 agricultural farms in Friuli Venezia Giulia

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The objective of this study was to investigate current levels of work safety in agriculture, based on interviews conducted in a composite sample of 103 farms located in the region Friuli Venezia Giulia (North-East of Italy). The survey has outlined a number of patterns that were consistently found across all types of farms and only slightly varied depending on farm size, type of production and location. The results were used to define guidelines for safety experts on the field with new, updated approaches for risk assessment and accident prevention in the farms.

A U.S. Approach Towards Safety Education for Youth in Agriculture

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In 1968, the U.S. Department of Labor (DOL) initiated the Hazardous Occupations Order for Agriculture allowing youth employment on farms/ranches at the age of 16; students aged 14-15 years could also be employed provided they participated in a mandated tractor/machinery safety program. In the 47 years since legislation, serious deficiencies and variations occurred in the type/quality of training and the overall process for certifying young workers. While a considerable amount of effort and funding was given to update the training, no real changes have occurred. More recently, the DOL attempted to place stricter controls on youth employment and was met with much opposition from the rural community and their agricultural lobbyist organizations. With politics aside, the more important topic was how to safely involve youth in agriculture. The overall objective of this national project was to develop a sustainable and accessible clearinghouse of safety and health curricula for youth workers. A group of dedicated stakeholders received funding by the U.S. National Institute of Food and Agriculture to coordinate a national approach for youth safety education. This plan involved interactions, collaborations, and partnerships from a variety of public and private institutions. The ultimate result was to provide appropriate training to the youth workforce that increased their awareness for hazards and improved safe practices. Along the way, there was a need to build capacity within the system for teacher education and access to quality curriculum, including testing tools that met a national education standard. Likewise, enhancing public perception of legislation was needed before any success could be attained. This paper addresses the steps taken by the national project, and three results attained thus far: 1) a national symposium for stakeholders' input, 2) a national clearinghouse for curricula, and 3) training for school students in a supervised agricultural experience.

Keywords: Young Workers, Training, Public Policy.

Risks linked to the management of pressured hydrogen within a photovoltaic-electrolyzer-fuel cell power system located on a rural land

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A power system formed by photovoltaic panels, alkaline electrolyzer and fuel cell stacks was designed and realized to supply the heating system of an experimental greenhouse. The barometric alkaline electrolyzer produces pressured hydrogen (3 MPa), which is stored inside iron tanks. The aim of this paper is to emphasize the main safety aspects of the power system connected to the management of the pressured hydrogen. From the safety point of view the electrolyzer unit has been equipped with devices able to highlight the malfunctions before they cause damages to the operators and break off the process of hydrogen production. The system can be reactivated after the repair just if the cause of malfunctioning has been removed effectively. Nevertheless the management of the products of the electrolysis process involves forethought and trained operators. Starting from the study of international directives and through the Hazard and Operability (HAZOP) Study method, the standards of safety systems for the hydrogen equipment located on a rural land have been estimated.

Keywords: Hydrogen Hazards Assessment, Water Electrolysis, Rural Lands, Risks Analysis.

TOPIC 6

“Environment Safety, People Health Protection and Welfare”

POSTER PRESENTATION

Analysis of the braking performance of counterbalanced forklift truck at varying of the tread wear

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The market provides tires for counterbalance forklift trucks with different kinds and depths of tread: the level of tire wear opens issues about the related safety level, in particular during braking. This research aims at verifying the effect of rubber solid tire wear on counterbalance forklift truck braking performance to verify braking performance compliance with regulations as well as standard requirements.

One counterbalance forklift truck was equipped with three different sets of rubber tires characterized by different wear levels provided that within the legal limits (new, wear, almost completely wear) evaluating its braking performance according to ISO 6292/2009 standard. Experimental activity was carried out driving the counterbalance forklift truck in two ballast conditions on three different kinds of surfaces: dry asphalt (according to ISO 6292/2009), wet asphalt and one low friction flooded surface. Different loads were applied on the brake pedal to evaluate the related braking behaviors (stopping distance and deceleration). Acquired data underwent statistical processing by means of Minitab 17.0 statistical package.

According to preliminary investigations, the kind of surface and the ballast the counterbalance forklift truck is subjected to, turn out to be the factors significantly affecting the braking performance while tire wear level does not seem to have a significant role. Further studies are nevertheless required to deepen the knowledge about the interaction between tire wear level and surface/ballast.

Keywords: Safety, Slick Rubber Tire, Wheel Locking.

TOPIC 7

“ROPS”

ORAL PRESENTATION

ROPS Design and Testing for Rigid and Foldable Structures

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While Roll-over Protective Structures (ROPS) are prevalent on agricultural tractors in the United States, an estimated 1.6 million tractors are still not equipped with ROPS. Many of these tractors do not have ROPS commercially available although they were originally designed to support a ROPS. To meet this need, a computer-based ROPS design program was developed to quickly develop ROPS designs based on tractor weights and dimensions. The final product from the program is the ROPS design drawings with specifications that can be used to construct the ROPS. The constructed ROPS would then need to be tested to assure it meet the appropriate ROPS standard. Two ROPS designed with the program successfully passed the SAE J2194 static longitudinal, transverse and vertical tests. Many ROPS being sold on new tractors use a foldable ROPS design. These ROPS are effective when the ROPS is raised and locked in place. But raising and lowering ROPS is a tedious and strenuous task, and many times ROPS are left down during tractor operations. Fatality reports are showing that operators are dying when tractor upsets are occurring with the mounted ROPS folded down. In one study the fatalities from tractor overturns with foldable ROPS down were 50% of the total tractor overturn fatalities examined. New OECD TAD/CA/WD(2014)8/REV1 defines the maximum forces to manually actuate a foldable ROPS. Forces measured on existing foldable ROPS far exceed those stated maximums. A simple mechanical foldable ROPS lift assist can ease in the raising and lowering of ROPS. A summary of foldable ROPS forces and the benefits of the ROPS lift assist will be presented.

Keywords: ROPS, Foldable, OECD.

Performance evaluation of a commercial tractor stability control system

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The study takes origin from the increasing development of aftermarket devices to evaluate tractor rollover risk on the basis of dynamic parameters detected by sensors.

Aim of the research was a tractors rollover risk assessment in normal field operation, using a commercial device to evaluate the activities at higher rollover risk for the agricultural operators.

Five tractors used in the experimental farm of the Bologna University were monitored in the 2013 year. Each tractor was equipped with a stability control system based on a hardware multisensory device, a software risk index algorithm and an integrated position information system for tractor localizing. The detected parameters and tractors position were accessible via a dedicated web site. Fourteen transceivers were connected to implements for recognition when coupled to the tractor.

Preliminary tests demonstrated that the tilt sensors used in the device did not provide high performance when the tractors were subjected to sudden operative changes. The risk assessment, in fact, was based on a quasi-static evaluation of stability conditions.

On the other hand the device seemed suitable to monitor dangerous practices in the normal operation of the tractor; the system could represent a good tool to educate unskilled drivers, becoming an acceptable compromise between safety evaluation and farm management.

Among the monitored operations the liquid manure spreading and the round baling were the ones at highest risk, while plough and rotary harrow were considered as tractor stabilizers.

Keywords: Rollover, Safety, ROPS.

Non-continuous rolling in modern narrow-track tractors

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Tractor rollover is one of the most hazardous event for the operator. Roll-Over Protective Structure (ROPS) was introduced to protect operator passively. In the specific case of protective structures in front of the drivers and fitted on wheeled narrow-track agricultural tractors, ROPS has to avoid the non-continuous rolling in the event of lateral rollover. Mathematical Model is included in the preliminary tests of the standardised testing procedures issued by the Organisation for Economic Co-operation and Development in order to check non-continuous rolling behaviour in narrow-track wheeled agricultural tractors. Modern narrow-track tractors fitted with rubber-tracks are currently designed but the standardised calculation does not cover the rubber-track tractors. The aim of the evaluation was to analyse the lateral tractor rollover behaviour as affected by the replacement of the tyres with the rubber-tracks. In the tested tractor the fitment of rubber-tracks replacing the rear wheels showed to increase the tractor mass and to affect the position of Centre of Gravity causing a downward and rearward shift with respect to the equivalent wheeled tractor. The track-ground interaction was different compared to the tyre-ground one. Mainly, the behaviour of the rubber-track with respect to the tyre at the state of unstable equilibrium under full load caused the rotation of the tractor around the outer edge of the track.

Keywords: ROPS, Rollover, Stability, Rubber-Track.

Experimental determination of operator perception of tractor instability

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Tractor instability is a major cause of serious injuries and fatalities in the agricultural industry. Thus, preventing tractor rollover can have a vital impact in reducing injury risk and saving lives of operators. This study presents preliminary experimental results on the perception of tilt angles. Using a novel tractor driving simulator developed at Penn State, a testing protocol was implemented in order to evaluate the ability of subjects to remember poses at various roll-pitch combinations. Results suggest that roll and pitch are both systematically underestimated, the former more severely than the latter. They also show no statistically significant correlation between the effect of pitch angles on the perception of roll, but do provide an upper bound on typical perceptual errors. These pilot-test results will serve as the basis of a comprehensive study with a wider subject pool. The bigger goal in this effort is to develop rollover alert systems that can prevent these accidents from happening. In that regard, the data obtained from this experiment can be useful in the design and tuning of predictive rollover alerts that promote safe operation of farm tractors, using human perception errors of roll and pitch to guide the thresholds at which warnings should be initiated in each of these directions.

Keywords: Rollover Protective Structure, Tractor Stability, Risk Perception, Stability Research.

Narrow-track agricultural tractors: a survey on the load of hand-operated foldable roll-bar

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To protect the operator in case of overturning, the narrow-track tractors (used in vineyards and orchards) can be equipped with a ROPS consisting of a 2-pillars front mounted foldable roll-bar.

The handling of this type of ROPS, in particular the transition from the horizontal (rest) to the vertical (protection) positions, is generally operated through two removable pins managed manually by the driver of the tractor. Apart the time necessary to perform some times a day this operations sequence, a moderate/medium physical load should be also required, given that often these roll-bars have a mass of some tens of kilograms. The reality is indeed quite different, since neglect and a poor attention to safety lead to the condition in which the foldable roll-bar remains continuously in the rest condition and is no longer moved back in the vertical (protection) position. Several roll-over accidents were fatal for the operator because the tractor, although equipped with a 2-pillars front mounted ROPS, at the time of the event had the roll-bar in the horizontal (rest) position, so assuring no protection to the driver.

This issue is quite serious. To remove at least one of the problems for the proper managing of this type of ROPS, the OECD have recently updated its Code 6, by introducing an optional test dealing with the manual handling of the front mounted roll-bar, providing a maximum load of 100 N.

Several tests on new roll-bars were carried out to ascertain the respect of this limit. The 100 N value is generally exceeded, so showing its criticism. Indeed, a more appropriate reference for the manual handling should be in this case higher load values (up to 250 N) already provided by several Standards for non-continuous tasks.

Keywords: Tractor Overturning, Front Mounted ROPS, Raising Force.

Design Considerations in fixture development to Retrofit ROPS on Agricultural Tractors

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Tractor population has reached about 5 million in India. Though being the largest tractor market, rollover kind of accidents have not got attention so far. Recent tractors are being equipped with safety devices such as SMVE, NSS and safety guards on moving parts. Stability sensors are also being thought-off to inform overturning situation. In fact, ROPS retrofitting is one of the best engineering controls for passive safety of rollover accidents through ROPS is not compulsory accessories of tractors. Therefore, operators' safety is at stack. Regulations coupled with design variation of various tractor models are hindering the use of market/common ROPS for retrofitting on tractors. Therefore, investigation has been planned to develop a fixture to retrofit ROPS to insure operators' safety.

To develop mounting fixture, medium range horse power tractors has been targeted. Two way approaches have been adapted to design fixture. First, in view of design of structural mount point and second, ROPS cross sectional view point. Structural mounting location is nothing but axle housing of various tractor models. These all have been clustered based on geometrical similarity of axle housing followed by strength predication of selected pre-ROPS axle housing. Alike to axle housings design parameter of ROPS were also considered.

It was found that most of the axle housing were circular in shape so as structural mount point. The critical diameter and thickness were varying about 90-250 mm and 14-18 mm respectively. Developed fixture could accommodate maximum of 70 mm × 90 mm prismatic cross section and up to 90 mm diameter of circular. Fixture was found capable of satisfying requirements of IS: 11821(Part 2) identical to OECD test code. Proper implementation of fixture along with regulation expected to reduce fatalities of tractor operator.

Keywords: ROPS Retrofitting, Axle housing, Design.

TOPIC 7

“ROPS”

POSTER PRESENTATION

Evaluation of the stability of an articulated farm tractor using mounted implements on hillsides

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When introducing a new farm tractor in the market, manufacturers undergo a tight homologation path under the supervision of the OECD centres technicians. Two of the most requested tests, although not mandatory for the commercialization of a tractor, are the individuation of the centre-of-gravity and of the lateral rollover angle on a tilting platform. The results of these tests are very interesting for the technical characterization of a vehicle but still far from its real working conditions, even if the tilting platform test forecasts, for example, the presence of fuel in the tank and the use of some weights to simulate the driver. Indeed, in this last test, no mounted implement (or equivalent mass) is connected to the tractor, hence limiting a lot the use of the results of the described tests.

Therefore, a numeric stability simulator was developed to overcome this problem, thus managing the variety of the possible implements to be connected to a tractor and giving the farmers effective indications concerning their vehicles' safety while working on hillsides. This simulator, based on a Newtonian approach, is able to compute the stability of a vehicle formed by a tractor and an implement.

It was used to verify the possibility of safety using some common mounted implements with a compact wheeled articulated tractor, specifically designed to work within terraced orchards/vineyards, common in mountain areas. This tractor was chosen because of its particular architecture: it gives the tractor a higher agility and a shorter turning radius than conventional tractors with the same dimensions, but also a very different stability behaviour, maybe not completely predictable in all situations by inexperienced drivers.

Keywords: Numerical Stability Simulator; Tractor+Implement Stability; Articulated Farm Tractor.



Section III

Ragusa SHWA - Full Papers

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Proceedings
International Conference
Ragusa SHWA

***“Safety Health and Welfare in Agriculture
Agro-food and Forestry Systems”***

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TOPIC 1

“WMSDs”

Agricultural Ergonomics Research and Outreach in California

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Abstract

Aims: The main aim of this paper is to give an overview of agricultural ergonomics research and outreach activities in California. Another aim is to introduce the California AgrAbility Program.

Methodology: A discussion about research publications on agricultural ergonomics is presented. In most countries, agriculture is recognized as one of the most hazardous industries, with musculoskeletal disorders (MSDs) being at the top of problems facing workers in labor-intensive agriculture. This talk gives an overview of the extent of MSDs in California agriculture, and a historical perspective on how ergonomics has been used to reduce the health effects of labor-intensive agriculture in California. The California AgrAbility Program is introduced and its main mission highlighted.

Results and Discussion: A summary of exposure to MSD physical risk factors within various classes of California crops is given. There are various administrative and engineering controls for abating MSDs in agriculture. These range from programmed rest breaks to mechanized or partially-mechanized operations. Worker-based approaches such as prone carts and platforms, and load transfer devices hold promise in combating the prevalent stooped work in agriculture. Although physical risk factors are major contributors to MSDs in agriculture, other psychosocial, organizational, cultural, and socio-economic factors could be important contributors to the development and prevention of these disorders. These factors may play a central role in the effective implementation and adoption of any intervention approach. Despite the advent progress in new technologies in agricultural practices, reliance on labor will always be a major cornerstone of agriculture for at least the foreseen future. An overview is given on how AgrAbility Programs in California and other US states have been assisting disable farmers and farm workers find solutions and other assistive technologies to maintain an active and productive work in agriculture.

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Keywords: MSDs, Ergonomics, AgrAbility, Labor-Intensive Agriculture

OWAS and REBA for the assessment of WMSDs in motor manual tree felling. Which is the best approach?

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Abstract

The risk to run into a Work-Related Musculoskeletal Disorder (WMSD) is very high when operating in the primary sector. As a matter of fact the number of professional illnesses related to the WMSD in Italy is high.

The study was carried out in the Autonomous Province of Bolzano (northeast of Italy), it consisted in the assessment of operator's postures during felling operations, through the assignment of a WMSD's index of exposure. This assessment was carried out with two different procedures: REBA and OWAS. A comparison of the results obtained from the two assessment tools was performed. In order to perform the assessment, every felling operation has been recorded with a digital camera, and it has been divided into three subtasks: pre-cutting operations, cutting operations and post-cutting operations. For each of them a frame capture every 10 second has been analysed.

The assessment of the OWAS and REBA's score shows that the OWAS standard has a general tendency to assign a lower index to exposure in comparison to REBA. This is evident both for subtask operations and for the whole felling operation. Moreover, OWAS, due to its easier technique for the assessment has shown a greater capability to assess body posture also in not clear situation because the operator was partially hide by a tree or far from the camera.

In conclusion, from this study it is possible to determine that OWAS assessment is able to perform a faster and more precise and sensitive assessment than REBA.

Keywords: Body posture assessment, Forestry, Chainsaw, Cutting operations

Introduction

In occupational medicine the illnesses caused by any physical stress during the work period are cumulatively defined as Work Related Musculo-Skeletal Disorders (WMSDs) (Colombini et al. 2010). Several reasons might cause the arising of a WMSDs such as when joints are subjected to overloads for a long period of time, mechanical stress, vibrations, low temperatures, static muscle load and wrong body posture and when micro-traumas tend to reoccur in time (Colombini et al. 2010; Kee & Karwowski 2007; Zanuttini et al. 2005). All these causes are constantly present when working in forest environments (Calvo 2009; Ashby et al. 2001). Therefore the forestry work is considered one of the most physical works (Slappendel et al. 1993; Gallis 2006) and it is characterized by a high demand of physical efforts. For lumberjacks, these efforts are the principal cause of muscular stress (Zanuttini et al. 2005; Li & Buckle 1999). The muscular stress is mainly caused by the static muscular operations required for the control and use of a chainsaw (Slappendel et al. 1993). Indeed, during the felling tasks, the lumberjack must handle firmly the chainsaw in order to perform the cutting of the tree in the safest procedures. As a matter of fact, forestry-based work can be described by a series of tasks which force the operator to handle for long time a chainsaw which he drives with small and repetitive movements of the upper limbs while he maintains an uncomfortable and unstable body posture due to the environmental and logistics

constraints. For all these reasons, the motor manually timber felling, is considered one of the heaviest, hardest, most uncomfortable and awkward jobs, which requires human strength (Gallis 2006; Gerasimov & Sokolov 2014). The operators employed in these tasks, together with the chokers setters (Gerasimov & Sokolov 2014), are the most affected by WMSDs (Gallis 2006).

In forest context the assessment of the body posture cannot be performed using dedicated sensors, because they can increase the risk of accidents as well as they limit the lumberjack's movements during the cutting. Therefore, the continuous monitoring with the use of instruments which permit the visual observation of the assessed person are techniques that are suitable to detect the level of discomfort due to the poor body posture assumed during working activities (Lasota 2013). Several visual techniques such as RULA (Rapid Upper-Limb Assessment), REBA (Rapid Entire Body Assessment), LUBA (Loading of the Upper Body Assessment), OCRA (Organizational Readiness to Change Assessment) and OWAS (Ovako Working Posture Analysis) are suggested in the literature for the body postural assessment (Li & Buckle 1999; David 2005; Lasota 2013). Among those, only REBA and OWAS assess the entire body (Karwowski & Marras 1998). Therefore those ergonomic tools will be tested for the WMSDs assessment during cutting operations, even if they have been developed for the ergonomic assessment in other sectors. While OWAS has been developed for the steel industry, REBA has been developed for health sector (Karhu et al. 1981; Hignett 1996; Hignett & McAtamney 2000; McAtamney & Hignett 2005; Zanuttini et al. 2005).

The goal of this research is to evaluate which is the best tool, between a low detailed assessment scoring system (OWAS) and a high detailed tool (REBA), to apply in the forest context in order to evaluate if the lumberjack works assuming good or poor body postures.

Material and methods

The study was carried out in the Autonomous Province of Bolzano (northeast of Italy), where the body postures assumed during 55 felling operations were assessed. The planned logging system foresees the use of a cable yarding, where the full tree system (FTS) is the logging system applied. This system consists in the harvesting of the entire tree via cable crane, without the processing of the branches and top. Sometimes could happen that the FTS is substituted by the cut-to-length logging system (CTL). At the contrary of the previous one, the operations of processing are performed in the felling area. Therefore, only the commercial assortment is exploited. Usually the CTL system is applied when is not possible to harvest the entire tree due to the overpassing of the payload of the logging system, or due to the difficulties encountered during the yarding as consequence of its big dimensions of the tree.

The ergonomic procedure consists in the assessment of operator's postures during the cutting operations, through the assignment of a WMSD's index of exposure. This assessment was carried out applying REBA and OWAS methods (Louhevaara et al. 1992; Hignett & McAtamney 2000). The methodology applied started with a video recording of each cutting thanks to the use of a GoPro® 3+. This camera was chosen because thanks to its 170° of wide-angle capture, the visibility of the entire operator's body at close distance was ensured. During each videotaping, the camera was placed in the lateral side with respect to the operator with a suitable angle that permitted the vision of his entire body. Therefore, the placement of the camera was very important in order to perform an accurate assessment. During the post-processing phases, thanks to the use of KINOVEA® software, every videos was divided in three main operations:

1. Pre-cutting operations: from when the operator starts to evaluate the felling direction and the presence of obstacles, to when the operator, gripped the turned on chainsaw, – lays the bar on the trunk;
2. Cutting: from when the operator lays the bar on the stump, to when the cut tree falls on the ground;
3. Post-cutting operations: from when the tree is completely laying on the ground, to when the operator moves to reach another tree. Stump grinding and cutting to length, if occurred, are considered in this operative phase.

For each one a frame capture every 10 seconds was taken using always the same software. These same pictures sets have been used for both REBA and OWAS assessments, in order to obtain the exposure index.

For the assessment of the REBA and OWAS score, the procedures already explained in literature have been followed (Karhu et al. 1981; Hignett 1996; Karwowski & Marras 1998; Li & Buckle 1999; Hignett & McAtamney 2000; McAtamney & Hignett 2005; Zanuttini et al. 2005; Jones & Kumar 2007). Both assessment are based on the visual evaluation of the body postures assumed by the subject during the tasks. OWAS and REBA are characterized to have a low detailed and high detailed assessment approach respectively due to the number of parameters assessed and the method of evaluation. The REBA method assesses both upper limbs separately and also because REBA evaluates 16 parameters against the 4 evaluated by OWAS method. While the OWAS performs a comparison among the postures assumed by the operator with predefined references, the REBA measures the angles that the joints assume during the work relatively to the neutral angles in resting position. For each parameter assessed, a score was defined. Thanks to the use of dedicated multi-entry tables and an equation, the calculation of the risk exposure can be performed. Anyhow the two system use two different scales of indexes, from those is possible to obtained the so called Action Class (AC), a scale which describes the urgency of an intervention in order to reduce the risk of WMSDs. While OWAS evaluates the AC from 1 to 4, REBA evaluates the AC from 1 to 5. Therefore, it is necessary an adaptation of the two methods in order to make a comparison between them. At this regards in specific literature (Kee & Karwowski 2007) are present works were in the REBA method the action classes 2 and 3 are clustered together in order to obtain a scale with 4 indexes (Table 1).

Table 1. Reclassification of the REBA scores according to OWAS.

Action classes	Scores		Risk level	Intervention required
	OWAS	REBA		
AC1	1	1	Negligible (1)	None necessary
AC2	2	2→7	Moderate (2)	May be necessary
AC3	3	8→10	High (3)	Necessary soon
AC4	4	11→15	Very high (4)	Necessary now

In the figure 1 the procedure followed during the study is summarized.



Figure 1. Description of the methodology followed during the research. The approach starts with the videotaping, than all the videos are divided into the main tasks (pre-cutting, cutting, post-cutting) and a capture frame with 10 seconds of interval was taken. Finally, each picture is assessed with OWAS and REBA tools respectively in order to have the final exposure index of the task.

Results

During the study about 10 hours of surveys were performed, where 55 felling operations have been recorded. For one of the recorded video the assessment was not possible due to a corruption of the video. From a first analysis of the videos, it appeared that for the 6% and 11% of the times the lumberjack did not perform the pre-cutting and/or the post-cutting operations respectively. This happened because some operations of pre-cutting or post-cutting were not necessary. In these cases, the operator, with the chainsaw turned on, starts the cutting as soon as he reaches the plant; otherwise the operator turns the equipment off and he moves to the next tree when the tree drops on the ground. Anyhow, the ergonomic assessment has been based on the evaluation of 852 body postures, divided in 142 pre-cutting, 549 cutting and 161 post-cutting respectively. Despite the care taken in the camera positioning not all the captures were assessable, due to a not easy detection of the parameters. Indeed, the operator moved around the tree to perform the cutting operations or due to his moving away from the camera in order to perform the CTL processing (Figure 2).

From this first consideration it is possible notice how the OWAS method, compared to REBA, has a greater capability to assess the cutting operations. Indeed the OWAS assessment, characterized to have a low detailed approach, is capable to assess body posture even if the target is partially covered by an obstacle (Figure 3). Therefore the OWAS tool permit to assign the scores in an easy way if compared with REBA.

Considering the three main tasks a comparison between them, considering the two ergonomics methods, was performed and it was reported in table 2. In the table 2 the results obtained considering the distributions of frequencies for each action class, recorded for each operative task, were reported.

Regarding REBA, slight differences were detected between the distributions about the action classes frequency for the two body sides. This happened as consequence of a different position of the upper limbs. In fact, sometimes happen that during the cutting the left shoulder and the left arm were raised or abducted, while the left wrist was bended to allow a firm gripping of the front handle of the chainsaw.

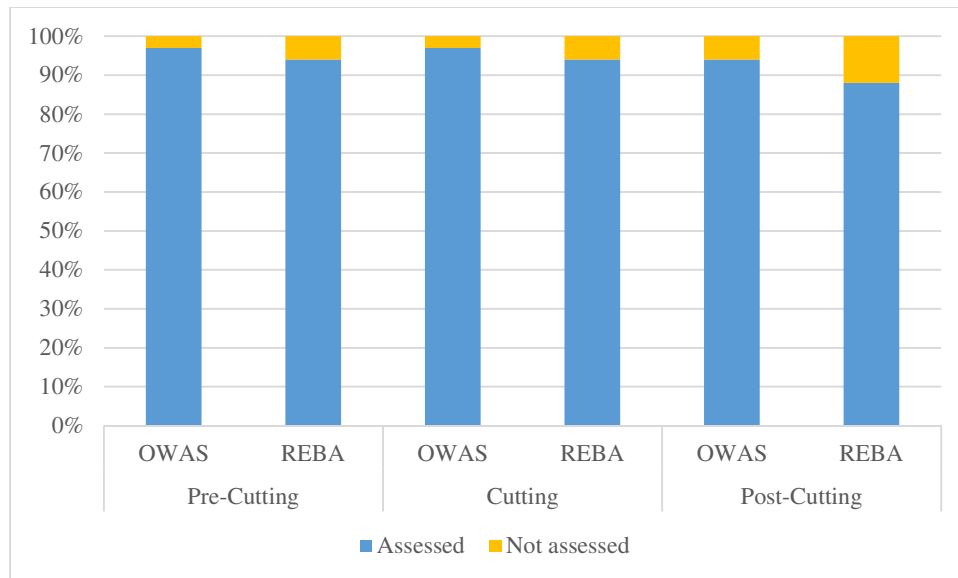


Figure 2. Distribution of the assessed and not assessed capture frames for OWAS and REBA methods respectively considering the three main operative tasks.



Figure 3. Examples of the body posture that must be assess. The picture on the left side is assessable by both methods, while the picture in the middle is not assessable, because the operator is coverade by the tree. The picture on the right is assessable only by OWAS, because the parameters necessary for REBA are not identifiable.

Table 2. Distribution of action category for the two ergonomic tools, in this only the assessable picture were considered.

		Action class			
		AC1	AC2	AC3	AC4
Pre-cutting	OWAS	33%	39%	22%	0%
	REBA (R)	0%	67%	26%	0%
	REBA (L)	2%	67%	24%	0%
Cutting	OWAS	4%	22%	70%	4%
	REBA (R)	0%	4%	91%	6%
	REBA (L)	0%	0%	91%	9%
Post-cutting	OWAS	31%	35%	22%	0%
	REBA (R)	4%	57%	28%	0%
	REBA (L)	4%	48%	37%	0%

Anyhow any statistical differences ($p < 0,05$) were detected between the sample from the right body side and the left one. Therefore, the upper limbs have the same weight on the final assessment of the risk exposure, even if they perform different movements. When the results obtained for both methods are compared it is possible to assess that OWAS method has the tendency to assigns scores lower then REBA (Figure 4). Considering the index exposure assessed for the different tasks, both methods evaluate the cutting operations as the most dangerous even if with different levels. The evaluation of the index of exposure for the pre-cutting and post-cutting operations have shown to have the same results if the same assessment tool is used. The cutting operation is resulted to be the more dangerous than the pre-cutting and post-cutting operations because the operator assumed a posture where he had both legs bent, or he was kneeling, with bent and twisted back. These body postures are assessed with high level of risk exposure by both assessment tool. Indeed, considering the scale of the action classes (Table 1) the 70% and 91% of the cutting task, respectively for OWAS and REBA assessment, require a soon intervention in order to reduce the risk to run into a WMSD. Considering the pre-cutting and post-cutting tasks it is necessary to investigate more in deep which are the causes of the moderate risk exposure.

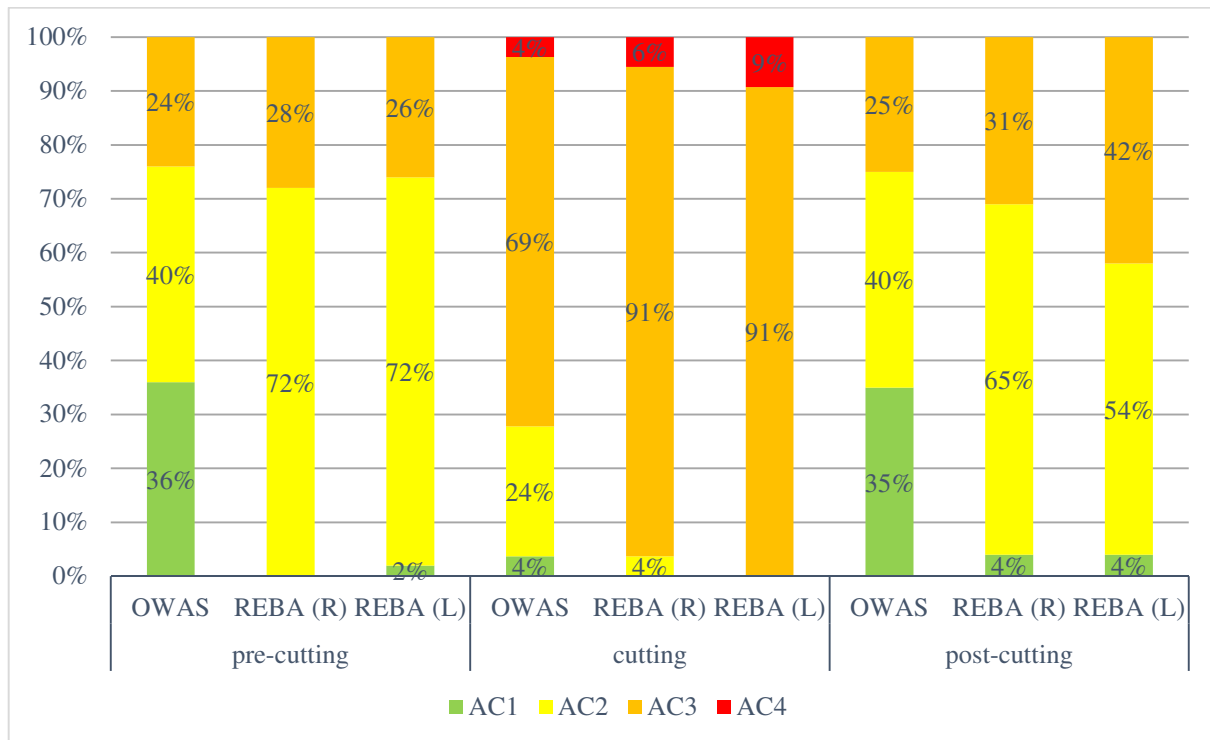


Figure 4. Distribution of the action level in relation to the main tasks.

Conclusion

Thanks to this research, it was possible to assess the body posture assumed by a lumberjack during felling operation, using two ergonomic tools: the OWAS and REBA. Considering the results obtained both methods have shown a good capability and reliability in the WMSDs assessment. In fact, the two methods have assessed 97% and 93% of the recorded pictures. The REBA tool assessed less body posture because the tool requires a high number of parameters, which sometimes are not detectable or they are detectable with difficulty. For instance when the operator is covered by an obstacle or when it is too far from the camera. Besides this, the amount of details required by the REBA assessment cause the introduction of subjectivity, uncertainty, and errors in the final assessment. This happens mainly when a parameter is not easily identifiable. Another aspect that influenced the number of the assessable pictures was the absence of a zoom in the camera. The camera employed has been very powerful for the film recording at close range, but it has shown to have limitations when the subject was distant. As matter of fact, during the post-processing the details of his body postures were not properly assessable due to the bad resolution of those pictures where the lumberjack was far from the camera.

In conclusion, it is possible to affirm that OWAS has shown the best characteristics than REBA to be used for the body posture assessment during motor manually felling, in forest environment. OWAS has demonstrated to be a faster, less biased tool due to the fewer parameters required and their easier assessment compared to REBA. Moreover, OWAS has shown a more flexible application being able to assess the subject even if partially hidden behind a visual obstacle, such as a tree. Thanks to these characteristics, the OWAS methods can be used to perform an assessment in real time. Since OWAS was developed for different purpose (steel industry), it does not take into account several body postures typically and

frequently assumed in forest operations, as well as the characteristics of the operation (such as vibrations or shocks or instable ground) which could be implemented in the approach. In the next step of the research an implementation of the traditional OWAS was taken into account in order to develop a tool more appropriate for the ergonomic assessment in forestry environment.

Acknowledgments

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Study of posture during plowing operations. Analysis of the pressures to the seat

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Abstract

With reference to the suspension system, the seats on the market are at the moment basically divided into three groups: mechanical, pneumatic suspended and active/semiactive seats. Since the end of the '60 studies on operator comfort to the tractor showed that the operation of the suspension of the seat is influenced not only by the design of the same, but also by the posture and dynamic behaviour of the driver. Many studies have been developed on the characterization of the stresses for the operator evaluating vibrations in different conditions, in agreement with the European Directives for the approval of seats. Interviews were conducted in the industry, which showed limb disorders whose cause could be related to the pressure against the seat.

It will be studied the interaction between the body and the seat of two operators recording the pressure values of 31 points in which were placed pressure sensors having a diameter of 100 mm². The recording of the data will be during the operations of plowing a field previously planted with corn. It will be recorded the pressure values in the two directions of plowing, alternately with the right and left wheel within the groove.

Processing of the data will allow the evaluation of the effect of stress on the seat to the two operators during plowing operations. Through geostatistical analysis will be realized a map could shows the barometric distribution of peaks. These maps could suggest the critical areas in which the body of the operator is affected by the higher stresses. The preparation of such maps, suggesting the critical areas in which the body undergoes the greatest stresses, can be a step for integration to the reading of the vibrations in the objective evaluation of the comfort of the seat.

Keywords: Comfort, Barometric maps, Agricultural tractor.

Introduction

Since the second half of twentieth century the agricultural machinery industry have realized that is necessary a system that can reduce strains to operator during his work-time. (Scarlett et Al., 2007). Seat has a very important role to reach this goal because it is the component of the strains transmission chain in intimate contact with the operator. Nowadays, in the market there are two main kind of seats: seats with mechanical suspension and seats with pneumatic suspension. In the first kind the elastic element is constituted by compression or tension springs, torsion bars or elastomer. The other kind of seat uses an air cushion to replace the spring function. There is also a new generation of seat that uses an active system of suspension that can reduce strains on operator reacting actively to excursion. Since the end of '60 studies on operator comfort to the tractor showed as the suspension functioning is influenced not only by the design of the seat but also by the posture and dynamic behavior of the driver (Suggs et al. 1969). Several studies on strains to operator have been developed evaluating the vibration (Gomez-Gil J. et al. 2014) in different conditions of work. Other works were conducted, under the comfort of the seats of the cars, observing the pressure of the body on the seat (Gyi et al. 1998/99; Kyung et al 2008). These studies are made following the indications of European Directive about seats approval (Directive 78/764/CEE, revised by

83/190 and 88/465). The aim of this work is to study a system of investigation of the seat based primarily on the pressure exerted by the body of the operator on the surfaces of the seat and in particular if a system of pressure sensors could be able to differentiate different test conditions.

Methods

It has been studied the interaction between the body of operator and the seat. The study was conducted placing 31 pressure sensors on the contact area between seat and driver. The sensors are made by Tekscan (model WELF-system) and they have an area of 1 cm², on which they record the peak value of pressure with a frequency of 10 recordings per second.

It was used, in all test conditions, a pneumatic seat with adjustable sitting, backrest and headrest. The seat was mounted on a tractor with suspension on front axle and on cab, but these suspension have been kept off during the test to maximize the stresses on the seat. The research was conducted with two operator with similar Body Mass Index (BMI) 23.7 ± 0.7 but with different experience to drive tractors.

The test protocol provided the recording of pressure value during a ploughing operation. Ploughing was made with an average depth of 0,30 m, on a field previously planted with corn.

The experimental plan provided to collect pressure values on the two directions, alternately with the left and right wheel within the furrow. Three replicates were performed.

Data was elaborated with geostatistical criteria using the software Surfer. This statistical elaboration permitted to observe the distribution of the stresses through maps of interpolated values.

Results

The data collected by the sensors 31 have resulted, through use of geostatistical software, maps of pressure distribution of the body on the seat. Figure 1-4 shows the map of the distributions of the beginner operator when the tractor is tilted to the right and figure y describes the same condition conducted by the experienced operator.

The peak values recorded in the contact area was 0,120 kg cm⁻², found on the right shoulder of the expert operator and the mean value obtained during the course was of 0,0282, collected looking backward, and 0,0473 looking forward. At the sitting the maximum values found was 0,045 for the beginner and 0,047 for the expert.

In the course conducted with the tractor tilted to the left, the maximum values in the sitting was 0,045 and average was 0,0296 for the beginner and for the expert was, respectively 0,047 and 0,0199.

The results obtained from processing of the pressure data show how the worst working condition happens, in the case of an experienced operator, when the tractor works with the right side within the furrow. In this case in fact, the expert operator in addition to having the center of gravity shifted to the right due to the inclination of the tractor continuously rotates to the right the trunk to control the operations of plowing.

Figure 1. Beginner operator, tractor on a slope to the right

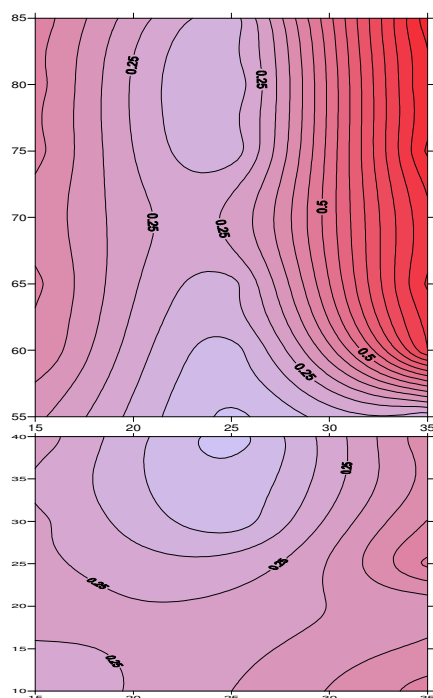


Figure 2. Expert operator, tractor on a slope to the right

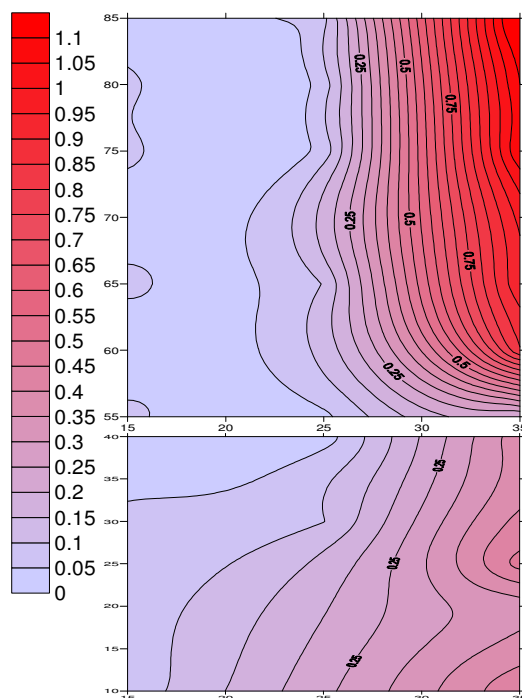


Figure 3. Beginner operator, tractor on a slope to the left

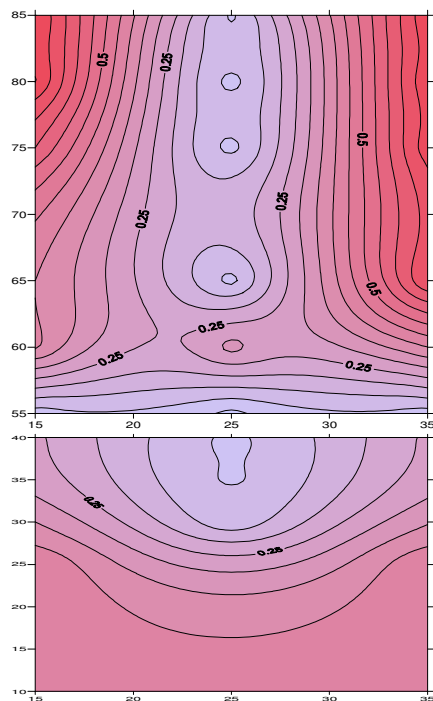
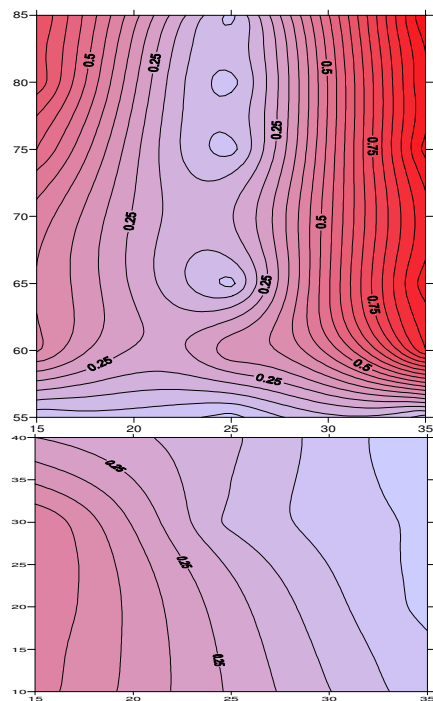


Figure 4. Expert operator, tractor on a slope to the left



Conclusions

This study of the pressures to the seat on the sitting and on the backrest of a tractor seat during ploughing operations have allowed to observe the distribution of the stresses through maps of interpolated values. The preparation of such maps, suggesting the critical areas in which the body undergoes the greatest stresses, may represent a step for integration to reading the vibrations in the objective evaluation of the comfort of the seat. The different experience of the operators has affected their posture: the first operator having little experience in plowing, drove with attentive look forward. The second operator, with well-founded experience in plowing, worked often with trunk reclined backwards in order to observe the behavior of the plough for the success of plowing. So the results of this study showed a heavy working condition, especially for expert operator that has been shown to use a posture with an effect more stressful the right shoulder. We should also consider that the experienced operator stays on tractor for an average time of 8 hour per day. So it is opportune make further studies about this topic, in order to evaluate other kind to working condition and to provide objective data to industry aimed at manufacture of more comfortable seats.

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A review of recent studies on the risk assessment from repetitive movements in agriculture

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Introduction

The aim of this paper is to carry out a review about recent studies concerning risks coming from repetitive movements in some agricultural activities (WMSDs, Work related Musculoskeletal Disorders). In agriculture, as in other sectors, the ergonomic studies take into account numerous factors such as the interactions man - machine (hardware ergonomics), the interactions man-environment (environmental ergonomics), the interactions man-organization. Over the years, the aims of ergonomics have gradually changed moving from improving the working conditions to the most complete idea of improving the efficiency of the production system.

Agricultural mechanization involves work organization, safety and wellness aspects, human resources, and also machinery, equipment and materials utilized, as well as the characteristics of the workplace; consequently, we can consider agricultural mechanization as a sort of meeting point between rural activities and ergonomics.

As concerns agricultural activities, Ergonomics deals with the dimensional and functional design of the jobs, taking in account techniques and work time (working shifts, working hours), the analysis of posture, of the movements and the physical demands.

In Italy, risk assessment for biomechanical overload of the upper limbs due to repetitive movements is performed using the OCRA method (Occupational Repetitive Actions). The OCRA method, which has been updated and modified over the years, it is recommended by ISO 11228/3, EN 1005-5, and its application is mandatory in Italy in the assessment of such risks (Art. 28 D. Lgs. 81/08). The OCRA method on one hand involves a highly detailed description of the work process and on the other makes possible to summarize the data derived from the analyses and to present a global vision of the work. The force is usually estimated by means of the Borg CR10 scale, which is used to evaluate the subjective perception of the strain level involved from the work.

Studies presented in the paper involve viticulture, tomato growing, nurseries in greenhouses, She – ass milking. Involved aspects are the influence of the frequency concerning manual operations, the strength concerning the various part of the hand measured by instrumented scissors specifically assembled.

Manual Pruning in Vineyards

Vineyard winter pruning is still carried out manually even when preceded by mechanized pre-pruning. Although facilitating equipment is becoming more widespread, traditional manual secateurs and long handled shears remain the most often utilized tools.

During manual pruning cuts follow on from one another regularly and rapidly, particularly when the pruning is preceded by a pre-pruning machine. Manual operations, which is characterized by high frequency and a stereotypic load on the upper limbs, can in time put the muscular skeletal system at risk and cause WMSDs.

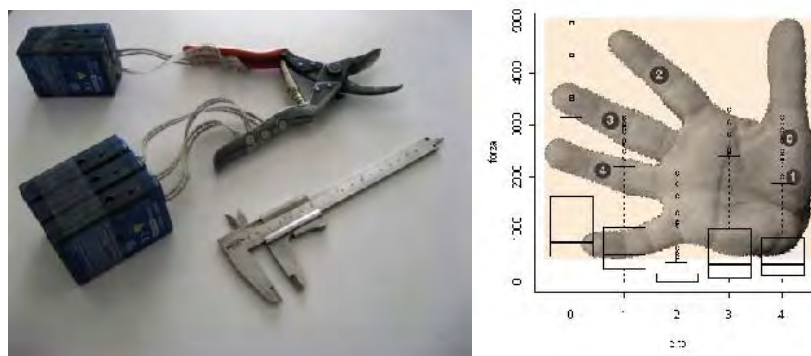
Preliminary studies were carried out by observing some agricultural jobs with the aim of enhancing risks indicators (repetitiveness, frequency, posture, strength), if they were. The results obtained led to focus on the level of risk due to repetitive movements of the upper limbs and trials were consequentially conducted. They involved most cultivars and the risk evaluation was conducted using the method OCRA.

So, seven vineyards sited in eastern Sicily were preliminarily studied, involving 30 workers and 12 hours of observation for each, 5 vine species (*Nerello mascalese*, *Nero d'Avola*, *Nerello cappuccio*, *Chardonnay*, *Merlot*) and 3 vine training systems (goblet cultivation, spurred cordon cultivation, guyot cultivation).

Vine species	vine training systems	Tool	Score Ocra Index	Risk
<i>Nero d'Avola</i>	Spurred cordon cultivation	Secateurs	5,56	medium
<i>Nerello Cappuccio</i>	Spurred cordon cultivation	Secateurs	6,22	medium
<i>Nerello Mascalese</i>	Spurred cordon cultivation	Long handled shears	5,52	medium
<i>Nerello Mascalese</i>	Sapling	Secateurs	5,55	medium
<i>Nerello Mascalese</i>	Sapling	Secateurs	4,92	medium
<i>Merlot</i>	Guyot cultivation	Secateurs	4,12	borderline
<i>Chardonnay</i>	Guyot cultivation	Secateurs	6,11	medium

The results have highlighted the presence of musculo - skeletal diseases factors related to manual pruning in viticulture. In addition, they led to investigate some aspects related to methodology OCRA. In particular, the experimental study involved two risk factors of primary importance, such as the strength and frequency.

As regards the strength, an instrumented scissor with sensors able to detect the stresses exerted by the hand during the cutting vine shoots has been developed in collaboration with the CRA-ING (Treviglio, Milan-EN) and utilized in laboratory. In according to the goals, the tool has proven useful to detect the stresses exerted by the different parts of the hand.

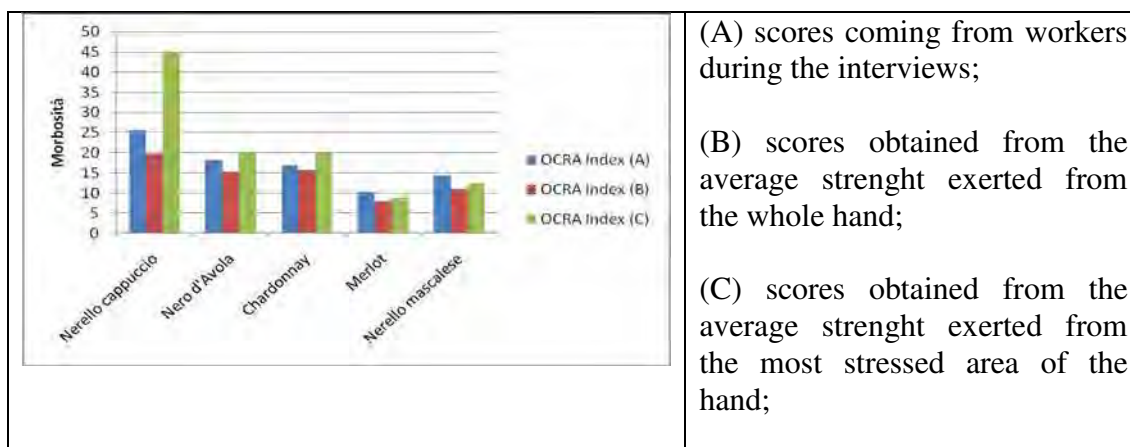


In parallel, a panel of operators was interviewed to verify the correspondence of the data provided by the scissors with the subjective evaluations of strength provided from each of the operators according to the Borg CR10 scale normally used for these kind of researches.

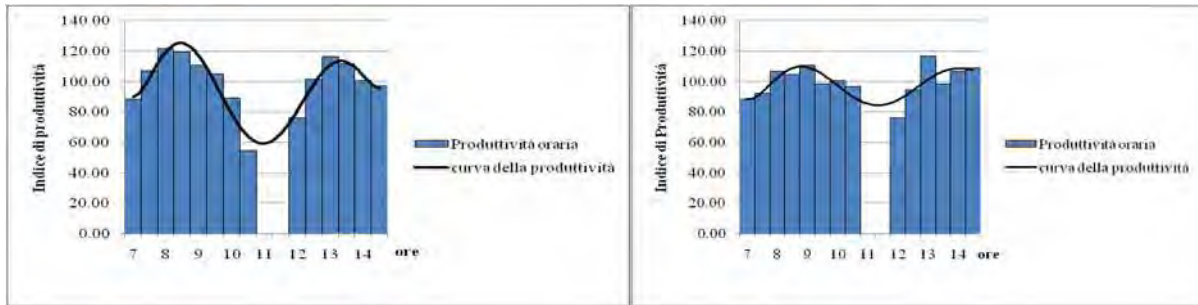
First of all, the instrument was able to reproduce measures consistent with the experimental plan; then, the interviews have allowed us to validate the instrument or, in other words, allowed us to correlate the values, obtained by the instrumented scissors, with the evaluations coming from the operators during the cutting operations.

The average values of the force derived from scissors tests, both those related to the entire hand and those concerning on the most stressed region of the hand, were converted in scores on the Borg scale using the procedure suggested by EN 1005-3.

The results of some simulations, conducted using those average values, confirm that during the cutting operation performed with common scissors some regions of the hand are more stressed than others. The methodology and the instrumentation used were able to highlight this phenomenon.



Trials enhance the cutting frequency changes during the day, but by drawing a curve fairly regular and characterized by two peaks and a minimum before the lunch, that is very similar to the variability showed in manual citrus harvesting. It means that surveys about frequency have to be carry out along the whole day if we don't want underestimate or overestimate the connected risks.



Tying the tomatoes in greenhouse

Growing vegetables in greenhouse obliges to perform the operations manually with risks due to in manual handling of loads and repetitive movements. Greenhouse tomato growing involves specific cultivation operations, such as green pruning, tying the plants and distribution of pesticides and fertilizers, manual harvest. Although they do not require particular effort, they involve repetitive movements of the upper limbs and often they induce the operator to assume incorrect postures.

The preliminary survey has revealed the presence of indicators of muscle - skeletal risks, such as the repetitiveness and the high frequency of the movements. They led it to investigate in particular the binding operations and the tomato topping. The investigations involved tying the plants on vertical support wires, and green pruning that can be done at the same time. The tying consists in manually twisting the stem of the tomato plant around a vertical support wire. The work of two sites was timed, each comprising 2 workers positioned on a mobile caterpillar platform.

The risk assessment was conducted by OCRA index, showing a value of 4.1, and proving that operations commonly performed in greenhouses can lead to the employee a medium risk of exposure to biomechanical overload.



Tying the tomatoes

First evaluation of the risk from repetitive movements in greenhouse nurseries: annual cycle and multitask analysis

The aim of this study was to develop an appropriate methodology in the field of musculoskeletal risk in horticultural greenhouse nurseries. This study was the starting point of a national work group made up of doctors and experts in the field of work organization, whose aim is to put together simplified methods (database, software) permitting the monitoring and management of biomechanical overloading risk in such complex situations as cultivation in protected environments.

Measurements were carried out in different nurseries located in eastern Sicily. The first part of the work consisted of the identification of the main sectors and tasks characterizing the activities in the (plant) nursery. The measurements were conducted using the technique of breaking the work into its elementary phases. The tasks were later filmed. Subsequently, the use of the OCRA checklist made it possible to assess the postural requirement (shoulder, elbow, wrist, hand) for each task and to quantify the biomechanical overloading of the upper limbs.

There are several activities in the nurseries where there is a risk of biomechanical overload due to repetitive movements of upper limbs and the manual movement of loads. The observations confirmed that nursery activities show a considerable risk and should be considered throughout the annual cycle.

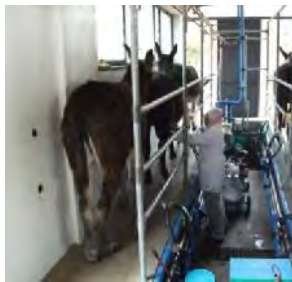
								
Manual sowing “operator seated”			Transplanting			Spraying		
Checklist OCRA	DX	20	Checklist OCRA	DX	14	Checklist OCRA	DX	16
	SX	20		SX	14		SX	4

Assesment of ergonomics studies concerning she-ass milking

In the farms in eastern Sicily the milking is either carried out manually or by means of a milking machine designed for sheep and goats but with some modifications made by adapting the type of milking liners.

As already demonstrated by research on cows milking is an activity characterized by repetitive movements, which in time can cause musculoskeletal stress. If the milker is at the same level as the cows, the back is bent and the trunk must bend for the udders to be reached; if the milker is in the milking pit the musculoskeletal risk is mainly to the upper limbs. Workers involved in the care of animals are subject to musculoskeletal disorders because of their work.

Recent applications of the Ocra method have concerned the risks deriving from repetitive upper limb movements of the workers during the milking of she-asses, given the demand for she-asses milk is increasing because of its recognized anti-allergic qualities. The evaluation was carried out in three typical farms situated in Sicily, through the analysis of the positions taken by the milker, of the times of the work phases and the subsequent processing of the checklist OCRA.



Farm 1



Farm 2



Farm 3

	Heads	In lactation	Type of milking		Duration	Checklist Score
Farm 1	80	18 – 20	A trolley milking machine	A milking parlour with milking pit	30 min	7.50 (dx)
Farm 2	70	12 – 14	A bucket milking machine	A milking parlour	30 min	5.75 (sx)
						2.25 (dx)
Farm 3	40	8 – 10	Manual milking	Outdoor	40 min	16,25 (sx)
						18,50 (dx)

The research shows that in she-asses farming workers are exposed to musculoskeletal risks due to repetitive movements and incorrect postures. Those equipped with a milking parlour with pit parlour show the same problems observed in cow farming, but the small number of head per farm makes small the connected health problems. More than 8 -10 heads shouldn't be manually milked but only by a bucket machine. As concerns the case studied, great part of the inconvenient (maintaining grip and incorrect postures) are due to the use of cluster not suitable for she- ass, but for sheep and goats. A simulation has shown that, in the meantime, breeders with milking parlour with pit parlour and trolley machine can reach number of heads able to increase net profits (around 50 – 55 heads in lactation) maintain low the biomechanical overload risks.

Conclusion

In the agricultural sector, the WMSDs risk evaluation was hampered by many factors: the lack of attention by the employers in the evaluation of risk, the lack of sensibility against the ergonomics specifically concerning workstations. Moreover, there are some general difficulties in the application of the methods (OCRA and or another) in open field that, as is well known, it's a very different environment from industry and manufacturing.

In addition, season factors influences the risk and the exposure of workers to biomechanical overloading depending on the task carried out; moreover, the risk varies for the same task according to intensity and duration. For the assessment of the risk should be considered throughout the annual cycle.

Instrumented scissors allow to recognize the strength exerted on different parts of the hand. The strength intensity reported by the instrument was correlated to the strength evaluation coming from a group of people and when necessary it can be converted in the Borg CR10 scale normally used for these kind of researches. Physicians could now utilize the measured strength intensity exerted in different parts of the hand with the aim to foresee the development of disabilities involving workers' arm and hand.

Results obtained from surveys on vine cutting frequency suggest that the daily curve that represents the cuts per min has to be identify correctly, otherwise the risk could be wrongly evaluated.

Obtained results highlight how is important a multi-disciplinary approach, putting together the competences coming from agricultural mechanization (that includes work organisation), ergonomics and occupational medicine.

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TOPIC 2

“Machine Milking, Animal Welfare, Sustainable Livestock”

Ergonomic issues and musculoskeletal disorders among ewe dairy workers involved in mechanical milking

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Introduction

In comparison to the traditional practice of hand milking, the use of mechanical milking equipment has considerably improved worker comfort and work efficiency of milking operations on sheep farms. Nearly 50% of Italian dairy sheep are located on the island of Sardinia, where 3.2 million head are raised on approximately 12,700 farms. Over the past 20 years, the industrialization of sheep husbandry has led to a marked increase in average herd size per farm (from 121 to 250 head) and to a large increase in milking mechanization.

Milking operations are mainly performed in parlor milking systems (82% of farms, average 275 head/farm), while bucket and trolley systems are used in small herds with less than 190 head. The parlor design is usually parallel based on a single or double stanchion row mounted along a milking pit where the worker operates. As an alternative, the stalls can be assembled on an elevated platform, either static or movable, thus enabling the worker to operate at the same level of the parlor. Among the low milk line systems, the parlor type with 24 stalls and 12 milking units (2 stalls/unit) is the most common configuration, while the type with 24 stalls and 6 milking units (4 stalls/unit) is the prevalent choice in high milkline installations. Considering the short milk emission period of the Sardinian ewe, one operator can usually manage about 6-8 milking units without incurring the risk of udder overmilking.

Although mechanization has reduced the physical load imposed on the workers, some studies have reported an association between the cow milking tasks and symptoms of musculoskeletal disorders (MSD) in the upper extremities and back (Nevala-Puranen et al., 1996; Stal et al. 2001; Douphrate et al., 2009; Kolstrup et al. 2012). Several studies suggest that MSD risk factors are mainly associated to the physical work environment in relation to the worker's anthropometrics (Stal et al. 2003; Jakob et al. 2012; Cokburn et al., 2015). Most of the scientific literature refers to dairy cow milking operations, while only limited information is available on ergonomics of sheep milking parlor systems (Pazzona, 1985; Billon, 2005; Berger 2001). The purpose of our study was to investigate the ergonomic design of ewe milking parlors and the prevalence of MSD symptoms among ewe dairy workers.

Methods

The study involved 30 ewe dairy farms and 36 workers (33 males, 3 females). General farm data, design of milking parlors and dimensions of the workplace were recorded, as well as detailed information about work organization and milking routines. Anthropometric and demographic data were collected on all participants. Information about health status, individual perception of the physical workload and symptoms of MSD in different body areas were recorded using a modified version of the general standardized Nordic questionnaire administered by interview.

Results

The herd size of the investigated farms ranged between 200 and 1850 total heads, with an average of 450 lactating ewes per farm (Table. 1). The number of operators varied from 1 to 5 per milking installation, with an individual workload of 50 to 450 ewes per worker per shift.

Table 1. Farm and milking parlour characteristics

	<i>Mean</i>	<i>Range</i>		<i>Mean</i>	<i>Range</i>
Herd size (head/farm)	634	200-1850	Parlor Milking systems (n)	26	-
Herd size (ewes/farm)	450	100-1500	Stalls (n)	42	24-48
Farm land (hectares)	123.3	30-430	Milking units (n)	12,4	6-24
Workers (n/farm)	2.1	1-5	Ewes/Milking units	3.9	2-4
Workload (ewes/worker)	231	50-450	Milking units/worker	7	2.4-16

Milking operations were performed mainly in parlors (26 over 30 installations) by low milk-line (14) and high-line (13) systems. The most common parlor configuration was 2x24 stalls with an average of 12 milking units (4 stalls/unit). Each worker managed typically 7 milking units, without any automatic cluster removers. In 5 cases this number was greater than 12 units/worker. This value imposes a very fast work routine to avoid the risk of incurring in overmilking after the milk emission time (50-60 seconds). This means also a high number of the operator's movements along the stall rows to promptly remove the milking unit and reattach it to the adjacent ewe.



Figure 1. Milking operation in a swing-over high milkline system

In 22 over 27 parlors' the operators performed their work inside a milking pit, while in the other five they were standing in front of an elevated platform. Bucket milking systems, which force the operator to milk in a squat body posture, were used in only 4 farms. Work place dimensions varied largely among the farms: the mean pit depth was 92 cm, ranging

from 78 to 110 cm. The pit width, which is important when two or more operators are simultaneously involved in the milking routine, was too narrow in three cases.

Anthropometrics of the operators that participated in the study (36 of 62) are shown in Table 2. Average male worker age was 44 ± 10.4 years and the range of work history in dairy was 20-30 years. Body mass indexes indicated workers were generally overweight with 12 meeting a case definition of obese ($BMI > 30$), which could increase the risk of MSD.

The physical design of the milking parlor was in many cases inconsistent with the anthropometrics of workers, especially for the women. Considering the neutral position corresponding to the waist height, it resulted that for about 30% of workers the pit was too high, and in three cases too low.

Average duration of farmer's workday was about 10 hours, but ranged between 12-16 hours in more than 30% of farms. During the lactation period (typically November through July) 42% of the worker's time was dedicated to milking tasks. Milking was performed twice a day, requiring on average 2.5 hours per shift including accessory operations. Longer milking sessions, more than 6 hours per day, were found in 7 farms with high numbers of ewes per worker. More than half of the workers perceived the milking task as “light” work in comparison to other farm operations as haymaking, soil tillage and animal care.

Table 2. Anthropometric data of dairy workers

	<i>Male</i> (N=33)		<i>Female</i> (N= 3)	
	<i>Mean</i>	<i>Range</i>	<i>Mean</i>	<i>Range</i>
Age (years)	44	26-63	40	35-47
Height (cm)	171	186-158	157	152-165
Weight (kg)	85	60-110	65	52-72
BMI (kg/m ²)	28	22-40	26	22-30
Shoulder height (cm)	142	130-154	130	125-138
Waist height (cm)	108	90-123	108	101-121
Arm lenght (cm)	62	40-71	55	52-59

During the last year, 6 workers suffered work accidents in operations other than milking. Among all 36 operators that participated in the study, 27 reported MSD symptoms located in several regions of the body and 9 of them have been out from work at least one day for this reason. Pain was located mainly in the upper back (44% of workers), shoulder (17%) and neck (17%), upper (28%) and lower (22%) extremities. Five operators said of suffering a continuous wrist pain.

When the workers were asked to specify which factors contributed the most to their physical discomfort, they indicated principally: working in awkward positions, maintaining the same posture for long periods, working in cold/hot/humid environment, handling and lifting heavy objects. Critical points were also considered the lack of pauses during the workday and the necessity of working even when suffering physical pain.

Conclusions

This study investigated the work environment and the health among milking operators in dairy sheep farms. The findings reinforce the importance of the ergonomic design of dairy

processes and milking parlor work areas to guarantee efficient and safe agricultural production methods.

Acknowledgments

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Manual Milking Ewes and the Risk of Carpal Tunnel Syndrome

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Introduction

The region of Sardinia, Italy is known internationally for the production of cheeses made from ewe's milk. Although most developed countries utilize automated milking equipment in ewe and cow dairies, the ancient task of manual milking is still performed in some countries and geographical locations (Kouyoumdjian and Machado de Araujo, 2006; Kutluhan et al., 2009). In Sardinia, Italy, manual milking of ewes is still performed on approximately 50% of ewe dairy farms. Both economic and cultural constraints have limited the adoption of modern dairy equipment by Sardinian ewe farmers. Automated milking equipment has been installed in 5,800 of the nearly 12,800 Sardinian ewe dairies. However, it is estimated that only 5,000 of the milking machines are currently in use. The under utilization of automated milking equipment is primarily due to the rise in milk production costs, which has driven the smaller farms to reduce energy and material expenditures. Additionally, ewe farmers have had to increase their flock size to stay competitive. Larger flocks result in longer periods of manual (hand) milking (Figures 1 & 2). Manual milking is a task that has been characterized as “a natural model for occupational carpal tunnel syndrome (CTS)” (Kouyoumdjian and Machado de Araujo, 2006). The purpose of this descriptive study was to evaluate the prevalence of CTS among Italian ewe farmers that manually milk sheep and compare them to a sample of cow dairy farmers that use mechanical milking equipment.

Methods

A random sample of 109 ewe farmers that manually milked was chosen from three regions in the north central part of Sardinia. Additionally a random sample of 75 cow dairy farmers that used mechanical milking equipment was chosen from two milk cooperatives also in the area near Sassari. Thus, the two groups came from similar social and territorial contexts. Demographics, hand symptoms, and electrophysiologic studies were obtained on 76 ewe farmers (70% response rate) and 56 cow farmers (75% response rate). A combination of hand symptoms and electrophysiologic studies were used in the case definition of CTS.

Interviews were conducted with both groups to determine age, height, weight, duration of time working in sheep / milk production activities, and a brief medical history checklist of systemic diseases (diabetes, rheumatoid arthritis, and hypothyroidism) that have been associated with CTS. The interviewers also addressed the presence of hand symptoms commonly associated with CTS. Participants were asked to indicate if they had any hand numbness, tingling, pain or burning within the past two weeks and instructed to rate hand symptoms on a 0-10 scale and describe the location of symptoms on a hand diagram. The hand diagram used in the present study was similar to other tools to assist in the evaluation of hand symptoms for the classification of CTS (Patil et al., 2012; Rosecrance et al., 2002; Anton et al., 2002). Hands were classified as having characteristic CTS symptoms if participants rated their symptom intensity at least 2 on the 0-10 scale and had numbness or tingling

localized in two or more fingers corresponding to median nerve distribution. The CTS symptom classification was similar those employed in other epidemiological studies of CTS (Armstrong et al., 2008; Patil et al., 2012; Rempel et al., 1998; Silverstein et al., 2010; Werner et al., 2005).

Electrophysiologic studies of the medial and ulnar nerves were performed on both hands of each participant. Nerve studies were conducted using the Cadwell Sierra II Wedge nerve conduction equipment (Cadwell Laboratories, Inc, Kennewick, Washington, USA). Electrophysiologic studies were based on the recommendations by the American Association of Neuromuscular and Electrodiagnostic Medicine (Jablecki et al., 2002).



Figure 1. Ewe farmer milking sheep by hand sitting at the rear of the animal.

Results

Average age of ewe farmers was 47.3 (SD 13.2) years and for the cow farmers 38.5 (SD 11.1) years. The ewe farmers had a history of ewe work for a mean of 29.1 years (SD 15.6) while the cow farmers were slightly less experienced with a mean number of years worked with cows at 22.7 (SD 12.8). The mean number of hours worked per day for all farmers was 9.11 (SD 1.9).

Forty-two of the 76 ewe farmers (55.3%) fit the case definition of CTS in at least one hand whereas 9 of the 56 (16.1%) of the cow farmers fit a case definition of CTS in at least one hand (OR 2.34 (95% C.I. 1.23-4.46)). All of the participating farmers continued to perform their regular dairy tasks despite having a case definition of CTS.



**Figure 2. Ewe farmer milking sheep by hand standing over the animal.
Note the hand milking of the ewe udder and teats.**

Conclusions

The prevalence of CTS among the participating ewe farmers is among the highest occupation rates of this disorder for any type of work. Carpal tunnel syndrome is a significant occupational health issue for ewe farmers that continue the traditional methods of manual milking. Interestingly, the ewe farmers continued to perform their daily work despite the presence of CTS. The recent trend in automated ewe milking machines may help reduce the prevalence of CTS among the next generation of Italian ewe farmers. It is also interesting to note the relatively high (16%) prevalence of CTS among the cow dairy workers. The cow dairy farmers conducted a wide variety of tasks around the dairy including milking parlor activities involving intensive upper limb motions (Figure 3). Patil et al., (2012) compared 66 milking parlor workers with 58 non-parlor workers in large US dairies. Using similar methods, the researchers reported a prevalence of CTS among the dairy parlor workers of 16.6% and 3.6% among non-parlor dairy workers. Thus, the prevalence of CTS among the cow farmers in the present study was consistent with US dairy workers conduction milking activities.



Figure 3. Milking activity (attaching milking cluster to teats) in mechanized cow dairy.

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TOPIC 3

“Instrumentation, Equipment, Periodic Procedures and Tests”

A laboratory test bench to analyse nozzle sprays

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Abstract

Aim of this study is to propose a low cost laboratory test bench, suitably designed to analyse nozzle sprays according to the procedure described in ISO 5682-1. It consists of a transportable trolley carrying a tank, a two diaphragms pump driven by an electric motor, and a spray boom carrying one multiple nozzle holder. The spray boom may move, under the control of a DC motor, along two slides placed above the working plane of the trolley. Acceleration and deceleration ramps may be imposed by the speed controller. According to the procedure described in ISO 5682-1, the test liquid is sprayed above Petri dishes placed on the working plane and containing silicon oil: analysing the images of the drops captured inside the oil, it is possible to measure the spray drop diameters and then all the spray features. The image acquisition system is under development.

Moreover, the test bench will be used to correlate spray features to water sensitive paper (WSP) images. Spraying at the same time Petri dishes and WSPs, the image of drops inside Petri dishes will be correlated to images on WSPs, so allowing the calculation of unitary deposits from WSP. Finally, the tests bench will be used to experimentally validate a model describing the WSP behaviour when sprayed with drops of assigned drop size distribution and volume median diameter. In this paper WSP images were produced by simulation, assuming some simplifying hypotheses: spherical drops and circular stains randomly placed on the images. Three types of spray were simulated (Fine, Medium and Coarse) with two drop size distributions (log-normal and Rosin-Rammler). The simulations showed that the unitary deposit can be derived from the measured percentage of covered surface on the WSP images, but the knowledge of the volume median diameter of the drops is necessary, independently of the probability distribution function of drop size.

Keywords: Pesticide Application, Image Analysis, Drop Pulverisation

Introduction

Spray deposit and superficial coverage are two of the main factors influencing the biological efficacy of a pesticide treatment as well as the environmental hazards. The correct deposit ensures the lethal dose on the target, while the coverage, for non systemic products, increases the probability of contact between pest and pesticide. Both aspects are influenced by many other factors, among which one of the most important is the spray spectrum (Hewitt, 1997; Matthews, 2004; Nuyttens *et al.*, 2007). The ideal spectrum maximises spray efficiency as ensures the transfer of the required dose to the target and minimises off-target losses due to drift and run-off (Hewitt *et al.*, 1998).

There are many drop size analysers available on the market nowadays, mostly based on optical imaging, laser diffraction, and phase doppler. Each analyser is best suited for specific types of testing; moreover, measurement techniques, type of drop size analyser, optical configuration, sampling methods, data analysis, and reporting techniques, all have a strong influence on the results, so that it is virtually impossible to compare data from different

instruments without a clear understanding of the test conditions and methodology (Schick, 2008).

In this paper a low cost laboratory test bench is presented. It allows nozzle spray characterisation according to the procedure described in ISO 5682-1. Moreover, the test bench will be used to correlate the spray features (drop diameter population, coefficient of variation, volume median diameter, arithmetic mean diameter of drops) with data extracted from water sensitive paper images (superficial coverage, particle density). If the correlations will be statistically significant, the WSP image analysis will make it possible both to measure the unitary deposit and to characterise the sprays issuing from nozzles.

Finally, continuing the studies on the simulation of the WSP behaviour at varying spray features and superficial coverage (Cerruto *et al.*, 2013), in this paper further results are presented regarding two drop size distributions (log-normal and Rosin-Rammler) and three types of spray (Fine, Medium and Coarse). The test bench will be used to validate the model and to confirm the results deriving from the simulations.

The laboratory test bench

The test bench under design consists of a transportable trolley with one working plane, carrying a 70 L tank, a two diaphragms pump “Annovi Reverberi AR 30 SP” with maximum flow rate of 36 L min^{-1} at pressure of 40 bar, driven by a 2.2 kW electric motor, and a spray boom carrying one multiple nozzle holder. This type of pump was chosen to be comparable with those installed in agricultural sprayers. Tank, motor and pump are positioned on the base of the trolley, near to the ground. The spray boom is applied to a mobile support that moves along two slides placed above and parallel to the working plane of the trolley, at a distance of about 0.5 m. The movement of the spray boom is realised by using anti-slip toothed belts connected to an axle powered by means of a DC motor with a speed controller. Maximum speed is about 1 m s^{-1} ; acceleration and deceleration ramps may be imposed by the speed controller. A schematic view of the device is reported in Figure 1.

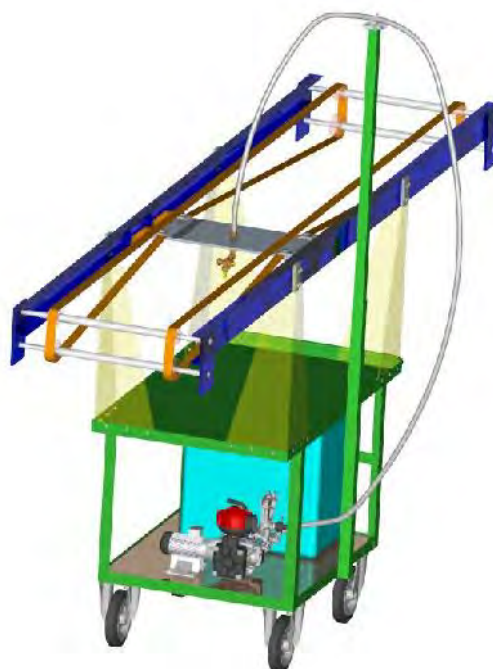


Figure 1. Schematic view of the test bench under development.

Following the procedure described in ISO 5682-1, the test liquid, a mixture with coloured dye tracer, will be sprayed above Petri dishes containing silicon oil of suitable viscosity placed on the working plane. The images of the drops captured inside the silicon oil will be acquired by means of a video system, at present under development, and will be analysed by means of an image processing software. The drop analysis will make it possible to measure all the spray features (probability distribution function of drop size PDF, volume median diameter VMD, arithmetic mean diameter AMD, coefficient of variation CV), as well as the calculation of the unitary deposit d_n (L cm⁻²). All data will be correlated with nozzle type and working parameters.

Placing water sensitive papers beside the Petri dishes, the data deriving from the analysis of their images will be correlated with those deriving from the analysis of the drops inside the Petri dishes: if the correlations will be statistically significant, the WSP image analysis will make it possible both to measure the unitary deposit and to characterise the sprays issuing from nozzles. Spraying in the same manner natural targets (fruits or leaves), it will be possible to correlate the unitary deposit on their surface, evaluated following well known procedures (Pascuzzi and Cerruto, 2015), to spray features and images of WSPs.

Finally, comparing effective and simulated water sensitive paper images, the test bench will allow the validation of the model (or will suggest appropriate corrections) and the assessment of the results obtained from the simulations.

Water sensitive paper simulation

WSP images were simulated using two drop diameter probability distribution functions, log-normal and Rosin-Rammler, widely used for describing drop pulverisation (Babinsky and Sojka, 2002; Schick, 2008). The PDF of the number of drops are:

$$\text{Log-normal: } f_0(D) = \frac{1}{\sqrt{2\pi}\sigma D} e^{-\frac{(\ln D - \ln \mu)^2}{2\sigma^2}}; \quad (1)$$

$$\text{Rosin-Rammler: } f_0(D) = \frac{k D^{k-4}}{\lambda^{k-3} \Gamma\left(1 - \frac{3}{k}\right)} e^{-\left(\frac{D}{\lambda}\right)^k}, \quad (2)$$

being D the drop diameter and $\Gamma(x)$ the gamma function. The scale (σ and λ) and location (μ and k) parameters are analytically correlated to CV, AMD and VMD of the drop diameters.

For each PDF three spray types were simulated, classified as Fine, Medium and Coarse (Hewitt *et al.*, 1998). They were obtained by changing the scale and location parameters of the two PDFs. The values chosen for the simulations are reported in Table 1.

Images of water sensitive papers (2 cm × 7 cm) were produced by simulation with a resolution of 1200 dpi, randomly allocating the stains, circular shaped. Given the drop diameter D (μm), the corresponding stain diameter D_s (μm) was calculated by using the Equation 3 (QInstruments):

$$D_s = 0.938 \cdot D^{1.143} \quad (3)$$

These simulated WSP images were treated as effective WSP images and then they were analysed by means of an image processing software, the *ImageJ* (Abramoff *et al.*, 2004). All data provided by the *ImageJ* were correlated with the reference ones used to produce the images so to analyse their trend at varying spray and image features. In this study the possibility of assessing the unitary spray deposition (L cm⁻²) at varying superficial coverage on WSP images and spray features was exploited.

All simulations, statistical analyses and graphical representations were carried out by using the R software (R Development Core Team, 2012).

Table 1. Parameters used for the simulations of the sprays

Spray type	VMD (m)	CV (%)	Rosin-Rammler			Log-normal		σ
			AMD (m)	k	λ (m)	AMD (m)	(m)	
Fine	141	70	70	3.874	155	52	43	0.631
	160	80	70	3.702	177	46	36	0.703
	181	90	70	3.576	201	41	31	0.770
Medium	261	70	130	3.874	287	96	79	0.631
	296	80	130	3.702	327	86	67	0.703
	334	90	130	3.576	370	76	56	0.770
Coarse	362	70	180	3.874	398	134	109	0.631
	410	80	180	3.702	453	119	93	0.703
	466	90	180	3.576	516	106	79	0.770

Results and discussion

The reference percentage of covered surface S^* (%), fixed without considering overlaps between stains, and that S_m (%) provided by *ImageJ*, measured with overlaps, were related as reported in Figure 2.

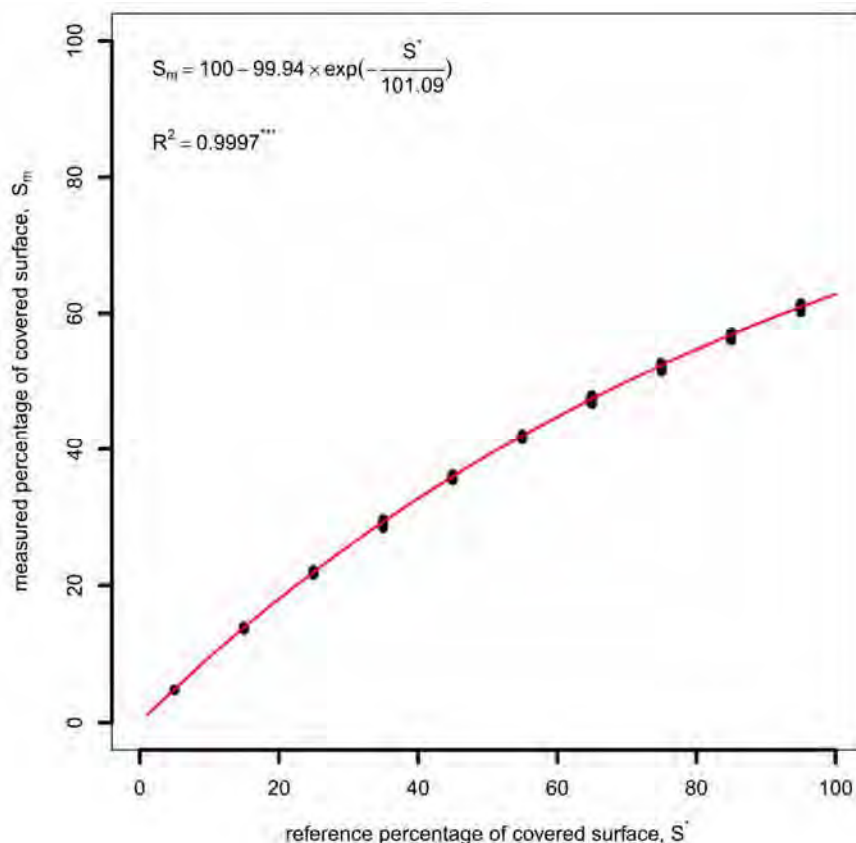


Figure 2. Correlation between reference S^* and measured S_m percentage of covered surface.

The correlation between S^* (%) and S_m (%) was described by Equation (4), independently of spray features:

$$S_m = 100 - 99.94 \cdot e^{-\frac{S^*}{101.09}} \quad (4)$$

This result confirms those of previous researches (Cerruto and Aglieco, 2013; Cerruto *et al.*, 2013), obtained considering sprays with log-normal PDF only. Probably it is independent of spray features, but could be affected by other factors (circularity of the stains, for example) that will be investigated in further researches. According to the Equation (4), the measured percentage of covered surface increases exponentially towards 100% when the reference one tends to infinity. This means that high values of percentage of covered surface are obtained with very high overlaps between stains.

The unitary spray deposit was related to the superficial coverage as reported in Figure 3 at varying spray type, PDF and CV of drop diameters. The graph shows that the spray deposit is primarily affected by spray type, then by CV and finally by PDF.

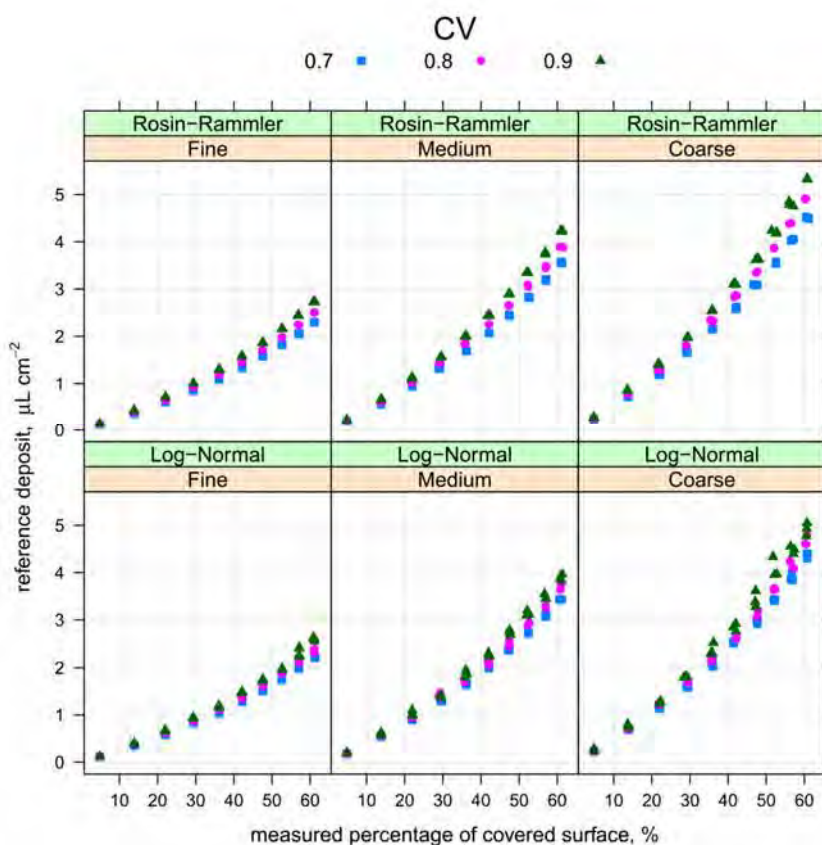


Figure 3. Correlation between unitary spray deposit and measured percentage of covered surface at varying spray type, CV and PDF.

Fixing spray type, CV and PDF, the trends of unitary deposit vs. superficial coverage were well explained by quadratic relations, with coefficients of determination ranging from 0.9949 up to 0.9996, highly significant. This result confirms the possibility of calculating the unitary spray deposit by known spray features and percentage of covered surface on WSP images.

Making explicit the effect of spray type in terms of volume median diameter VMD, the graph of Figure 4 was obtained. As expected, it shows a strong effect of VMD and a negligible effect of PDF.

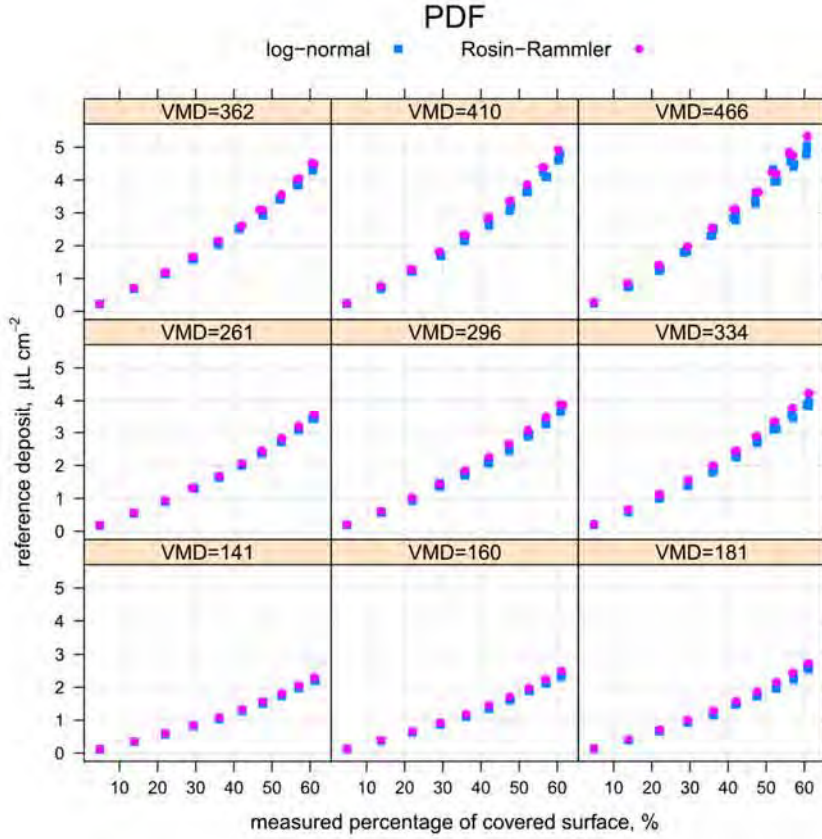


Figure 4. Correlation between unitary spray deposit and measured percentage of covered surface at varying volume median diameter VMD and PDF.

Taking into account only the volume median diameter VMD (m) and using a multiple regression approach, the unitary deposit $\hat{d}_n$ (L cm⁻²) can be calculated according to the Equation 5:

$$\hat{d}_n = 10^{-6} [12770 + 8169 \cdot S_m + 124.7 \cdot S_m^2 + \text{VMD} \cdot (189.7 + 72.26 \cdot S_m + 1.242 \cdot S_m^2)] \quad (5)$$

The regression equation had determination coefficient R^2 equal to 0.9952, highly significant. The relative error between reference d_n^* and computed $\hat{d}_n$ unitary deposit, calculated according to Equation 6:

$$e = \frac{d_n^* - \hat{d}_n}{d_n^*}, \quad (6)$$

ranged from -23% up to 8%. The highest relative errors were detected estimating low unitary deposits (less than 0.05 L cm⁻²), whereas in other cases the error was less than 10% (Figure 5). A better estimation can be obtained by including in Equation 5 the effect of PDF.

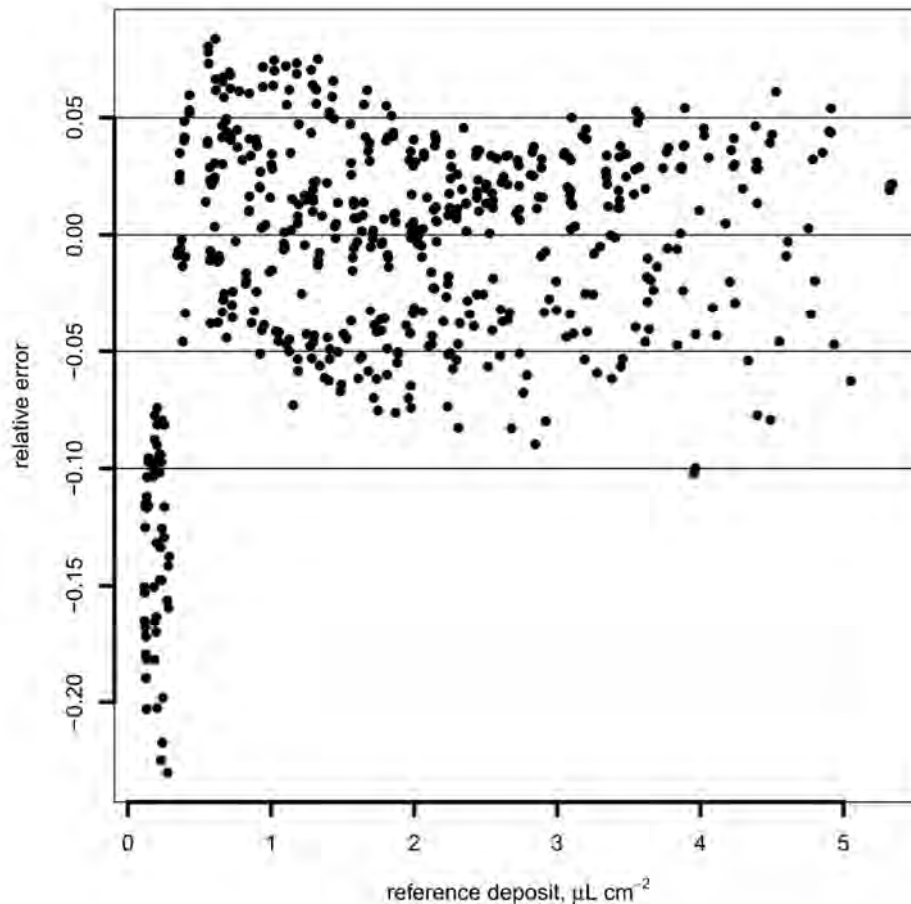


Figure 5. Relative error on unitary spray deposit when computed by using Equation (5).

Conclusions

The results of this research provided some important hints for further developments of the study. In particular:

- Reference and measured percentage of covered surface on water sensitive paper images were related by a simple relation (Equation 4), independently of the spray features. This allows a quick estimate of the overlap between stains by measuring the percentage of covered surface, the easiest parameter to measure during the analysis of WSPs.
- The spray unitary deposit can be estimated from the percentage of covered surface, but the knowledge of the spray features is necessary (spray type and CV of drop diameters). As a first approach, the unitary deposit was estimated, with a relative error in most cases less than 10%, knowing the volume median diameter only (Equation 5).
- The test bench under development should be suitable to validate (or suggest corrections to) the model used to simulate the behaviour of water sensitive papers. When it will be completed and available for experimental activities, it will be possible to correlate the data extracted from the WSP analysis (superficial coverage) to spray features and unitary deposit on natural targets, parameters strictly correlated to the efficacy of a pesticide application.

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Evaluation of pump-over thermal effect during red grapes fermentation: preliminary results

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Abstract

In oenology, pump-over is a mechanical technique used to enhance the fermentative maceration. Pump-overs are conducted, with or without air contact, by taking the must from the bottom of the fermentation tank, and using it to spray the cap. The aim of this practice is the enhancing the phenolic and volatile compounds extraction from grape skins. Consequently, wine quality is improved in this way.

During some temperature monitoring tests a “secondary” effect of pump-over has been highlighted. Temperature affects volatile and phenolic compounds concentration too. Particularly, low temperatures may be used to improve volatile production by yeasts during fermentation, and regulate the extraction of polyphenols compounds from the solid to the liquid phase.

The aim of the work is to describe the thermal effect of pump-overs with and without air contact during a red fermentation.

Tests have been performed during the September 2014 Tenuta Argentiera (Bolgheri (LI), Italy) in a tank of 20 m³ capacity. Six probes were placed into the fermentation tank, for temperature monitoring in different zones during pump-overs.

Both kinds of pump-overs produce two main effects during fermentation: a temperature homogenization, reducing the differences among the zones of the tank, and a cooling effect, reducing the average temperature of the must. Hence, in addition to their effect on compounds extraction, pump-overs could be useful to reduce and control the temperature during red fermentation.

Keywords: Quality, Temperature, Wine.

Introduction

During alcoholic fermentation of red grape berries for wine production an ascending flux of carbon dioxide is produced. Gas bubbles carry up the solid parts (i.e. grape skins) to the liquid-air inter-phase, arranging the marc cap. The cap releases to the must compounds important for wine quality such as anthocyanins and tannins. Furthermore, it contains a large number of yeasts: about $150\text{-}200 \times 10^6$ colony forming units per ml, while on the bottom of the tank this numbers is reduced 3 times (Riberau-Gayon et al., 2004).

In order to improve the extraction process from the marc cap some methods of different nature have been developed. Among these the most common are physical (maceration length, temperature, carbon dioxide pressure), chemical (sulphur dioxide addition), biochemical (maceration enzymes), and mechanical (pump-overs, delestage, and cap punchings) (Bosso et al., 2009).

In pump-overs the juice is drawn from the base of the fermentor and pumped to the top. Then it is sprayed onto the skin cap. Depending on the desired level of juice air exposure, pump overs could be done in closed conditions (almost without air contact), open conditions

(must is splashed in a vat before its reintroduction in the fermentor), or with an in-line Venturi (Moenne et al., 2014). Pump-overs promote color and flavor extraction, incorporate oxygen into the must, and homogenize sugar and yeast concentration as well as temperature (Riberau-Gayon et al., 2004). Furthermore, some wineries use pump-overs for juice cooling. In this case the must passes through an heat exchanger during the operation (Boulton et al., 1996).

In literature, there are few works focusing on the effects of pump-overs on wine temperature. In 1951, Ribereau-Gayon and co-workers demonstrate that pump-overs could decrease the fermentation time, by increasing the temperature through the increase of yeasts activity. Boulton and co-workers (1996), on the other hand, focused on the temperature homogenization provided by pump-overs. Furthermore, Boulton et al. (1996) describe a procedure to remove the fermentation metabolic heat during a pump-over. Particularly, the juice cooling is obtained by passing it through an external heat exchanger before its re-insertion into the tank. Despite the importance of the fermentation temperature, in literature, a detailed picture of the effect of pump-overs on the thermal homogenization, and the removal of metabolic heat is not provided.

Materials and Methods

Tests were carried out during the vintage (September and October) 2014 at Tenuta Argentiera (Castagneto Carducci (LI), Italy). The experimental tank had 200 Hl of nominal capacity, and was provided with an automatic pump-overs with a hydraulic pump controlled by an electronic control panel. Furthermore, the tank was equipped with two heating/cooling jackets: the first was arranged from the bottom (0 cm) to 60 cm height, and the second from 130 cm to 190 cm height. The tank's internal diameter was 2.9 m and the steel thickness was 1 cm. Two poles were put into the tank, bringing 3 temperature probes each (WatchDog DataLogger, Spectrum, US). The first pole was put at 60 cm height, and the second pole at 124 cm height. The probes were put at 20 cm from each border, and in the middle of the pole. The temperature acquisition frequency was 1 data every 5 minutes.

The tank was filled with 170 Hl of red juice and berries (cv. Merlot), with the chemical analyses reported in table 1.

Table 1. Chemical parameters of the grape must used during the tests.

Parameter	Value
Relative Density at 20 °C (kg/dm ³)	1.09446
Total acidity (g/l of tartaric acid)	5.72
pH	3.58
Malic Acid (g/l)	2.15
Glucose-Fructose (g/l)	219
Assimilable Nitrogen (mg/l)	99
BABO at 15°C	18.6
Potential ethanol (% vol)	12.7

In the study, 8 pump-overs were analysed: 2 with air contact, and 6 without. Among the 6 pump-overs without air contact 3 have 4 minutes length, and 3 have 6 minutes length. The

pump-overs were performed as scheduled in table 2.

Table 2. Scheduling of the monitored pump-overs.

Day	Opened/Closed	Length
3	Opened	40 min
3	Closed	4 min
3	Closed	4 min
4	Closed	4 min
4	Opened	15 min
4	Closed	6 min
4	Closed	6 min
5	Closed	6 min

Results and Discussion

The alcoholic fermentation trend is shown in figure 1, and the monitored pump-overs are displayed in the plot with eight lines.

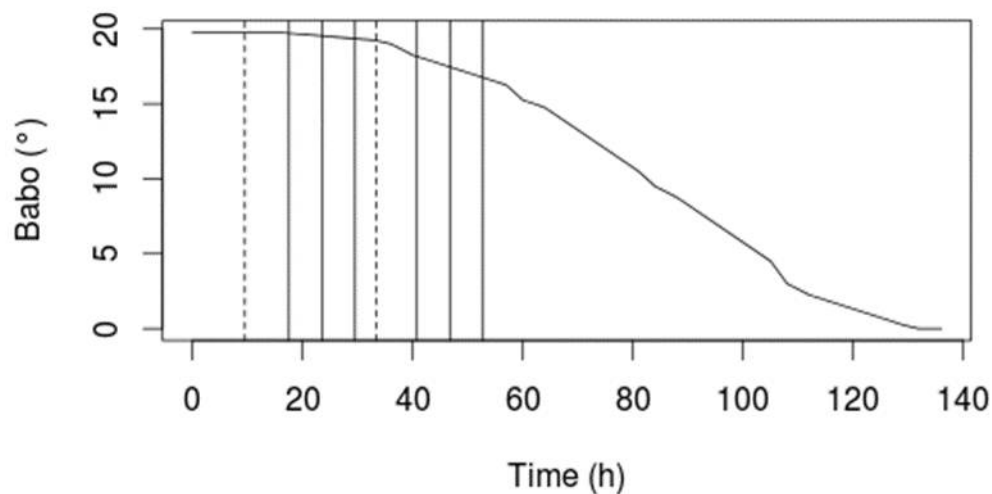


Figure 1. Alcoholic fermentation trend. The pump-overs are reported with dotted lines (with air contact) and with continuous lines (without air contact).

The eight pump-overs were performed during the tumultuous phase of the alcoholic fermentation and, particularly, during the day 2 and 3. During the considered time, the temperature increase from 22.5 °C, to roughly 25.0 °C.

Figure 2 shows the average temperature of the six probes on the fermentation tank.

With a continuous monitoring it is easy to see the cooling effect of pump-overs, which are clearly recognizable by the drops in temperature.

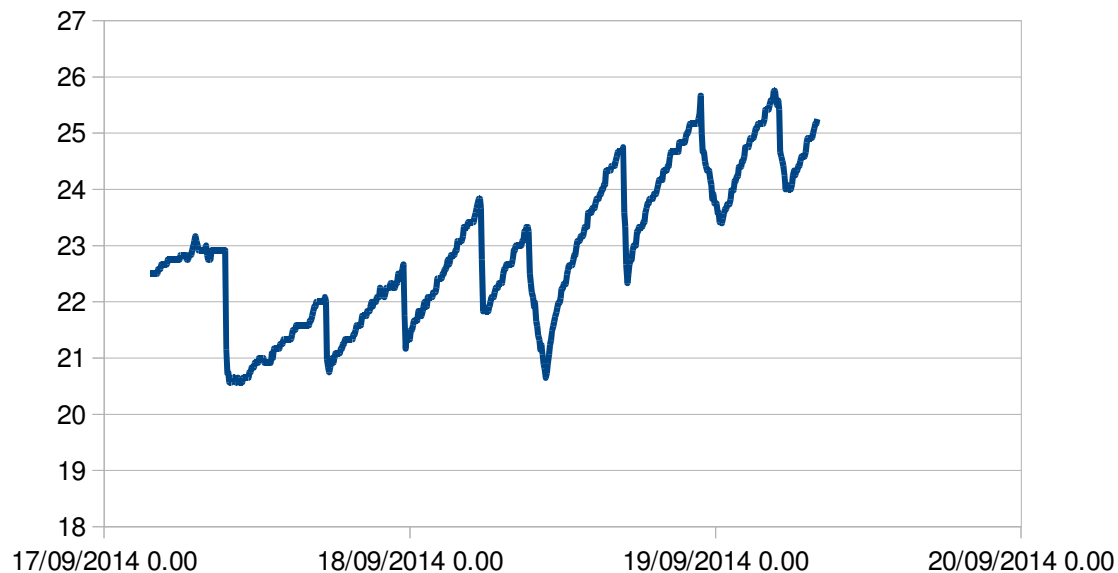


Figure 2. Mean temperature recorded in the tank during the fermentation

On the average, pump-overs were able to remove 2.0 ± 0.5 °C. The two with air contact remove 2.3 °C, and 2.6 °C, while the six closed pump-overs remove, on the average, 1.9 ± 0.5 °C. The closed pump-overs remove in 4 minutes 1.6 ± 0.4 °C, while they remove 2.2 ± 0.4 °C in 6 minutes. At a t-test the probability related with the equality of the two population is 0.1. However, they remove almost the same amount of fermentation metabolic heat per minute: 0.39 °C/min for the 4 min length, and 0.37 °C/min for the 6 min ones.

The cooling effect, in a open-system, could be easily explained with the must contact with the environment. In fact, during both open pump-overs air temperature was 18 °C, while the must temperatures were about 23 °C. Hence, the contact between must and air produces, in these pump-overs a cool down effect. On the other hand, this effect is also exhibited when the system is not in contact with environment, or rather, during the closed pump-overs.

A possible explanation of this phenomenon could results from an analysis of the heat transmission in to the tank. The must, as well as all the fluids, when it is not at the thermal equilibrium state, transports mass and heat with the convection mechanism from the hottest to the coldest zones. Since during the winemaking process, the metabolic heat produced by yeasts on one side, and the heat removal due to the cooling jacket on the other side, produce high temperature difference in the tank (Guerrini et al., 2015) it is possible to assess that a convection transport is established. In these conditions, a thin layer of flow (wall layer), close-fitting the wall of the fermentor that, moves very slow, is formed. This thin wall layer, partially blocks the heat transmission by convection, providing an insulation, slowing down the heat transfer, and thus reducing the exchanging efficiency of the cooling jacket (Knudsen et al.,1999)

It could be supposed that pump-overs, increasing the recirculation speed of must in the tank, break this wall-layer. Thus, they could produce an improvement of the thermal exchange

efficiency, which lead to a significant decrease of the temperature in the tank.

Finally, the pump-over homogenizing effect has been assessed with the measurement of the standard deviation among the six probes, before and after the treatment (Table 3). The values of standard deviation decrease after the treatment, confirming the known homogenizing effect of pump-overs (Boulton et al., 1996).

Table 3. Homogenizing effect of pump-overs. SD is the standard deviation among the probes

Day	Opened/Closed	Length	SD Before	SD After
3	Opened	40 min	0.80	0.25
3	Closed	4 min	1.54	0.39
3	Closed	4 min	0.87	0.69
4	Closed	4 min	1.39	0.59
4	Opened	15 min	1.86	0.45
4	Closed	6 min	2.13	1.70
4	Closed	6 min	2.17	2.78
5	Closed	6 min	2.97	1.24
mean			1.72	1.01

Conclusions

The main thermal effects reported from the use of the pumps-over are homogenization of temperature, and cooling. The cooling has been recorded in both pump-overs: with and without air contact. Cooling is due to the thermal exchange with the air, and to the increase of the exchange efficiency. The latter phenomenon needs to be clarified with further tests. However, pump-overs (open and closed) could be useful to help the cooling system to keep the desired temperature during the alcoholic fermentation.

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Hose reel vs dripline irrigation systems: which is better from Carbon Footprint standpoint?

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Abstract

Irrigation plays an essential role in the cultivation of crops but it also has a relevant contribution to the environmental impact of agriculture. The present work analyzes the Life Cycle of hose reel and dripline irrigation systems, with the aim of evaluating and comparing their carbon footprint. LC analysis was carried out using the software Simapro, with the support of the Ecoinvent Database. Although water consumption is the main indicator used to assess efficiency of irrigation, it is not sufficient to evaluate its overall sustainability. Indeed the use of irrigation equipment and machines cause a large amount of GHG. The GHG of the irrigation systems have been assessed by analyzing two stages of their life cycle: production and use phases. Production phase encompasses all the impacts due to the machine industrial manufacturing from raw material extraction and processing, to production and assembly of the various components. Use phase considers the impact due to energy consumption for water distribution to the field. The functional unit is the m3 of water distributed under average technical and climatic conditions of central and northern Italy. Results show that dripline systems give rise to the highest GWP. Their high impact is due to their short lifetime, since they have to be replaced annually. On the other side, the lifetime of the travelling rain gun span for over 15 years and therefore their production impact has a lower contribution able to compensate the higher impact of the use phase due the high water working pressures.

Keywords: Irrigation; Carbon Footprint; LCA.

Introduction

Agriculture manipulates ecosystems to produce food and fiber. This principle is common both to early and modern agriculture. However, modern agriculture went through a massive increase of food production, which doubled in the last 35 years (Pimentel, 1992). This increase in productivity has been achieved thorough the introduction of new cultivation technologies and techniques, to respond the continuous global increase of food demand. The increase of agriculture production requires a vast amount of resources and it causes a vast series of environmental impacts, which represent a threat to the natural ecosystems of the world. Some of these are related to resources depletion, Eutrophication of marine ecosystems and, last but not least, contribution to global warming (IPCC, 2007). Therefore, to maintain agricultural sector and food production sustainable, it is necessary to identify the technologies and techniques with lower environmental impacts. Irrigation plays an essential role in crop cultivation and yield rates boost, and at the same time, it is one of the agricultural techniques with the highest environmental impacts. This study assesses the contribution of irrigation technologies to climate change. Although poorly understood, climate change is an urgent threat to agriculture and food security. The irrigation sector will be strongly affected by climate change, as well as by changes in the effectiveness of irrigation methods (Tilman, 1999). Therefore, it is necessary to identify irrigation techniques, which make an efficient use

of water and have a low environmental impact in terms of climate change contribution. Efficiency of water system is extensively studied in literature but very few works assess the impact of irrigation in terms of contribution to climate change.

This study assesses the carbon footprint (CF) of two widely used irrigation technologies: a hose reel machine equipped with a travelling rain gun and dripline systems. CF measures the total amount of Greenhouse gas emissions of a defined population, system or activity, considering all relevant sources, sinks and storage and therefore their Global Warming potential, measured in Kg of CO₂ equivalent (Wright et al., 2011).

Materials and Methods

The methodological framework adopted in this study is based on a life cycle assessment (LCA) of the two irrigation systems, in accordance with the standards ISO 14040 and ISO 14044. The aim is to provide a cradle to field analysis, which comprises the environmental burdens of the systems' production and use phases. Production phase encompasses all the impacts due to machines industrial manufacturing from raw material extraction and processing, to production and assembly of the various components. Use phase considers the impact due to the energy flows during water distribution to the field. System boundaries are presented in figure 1.

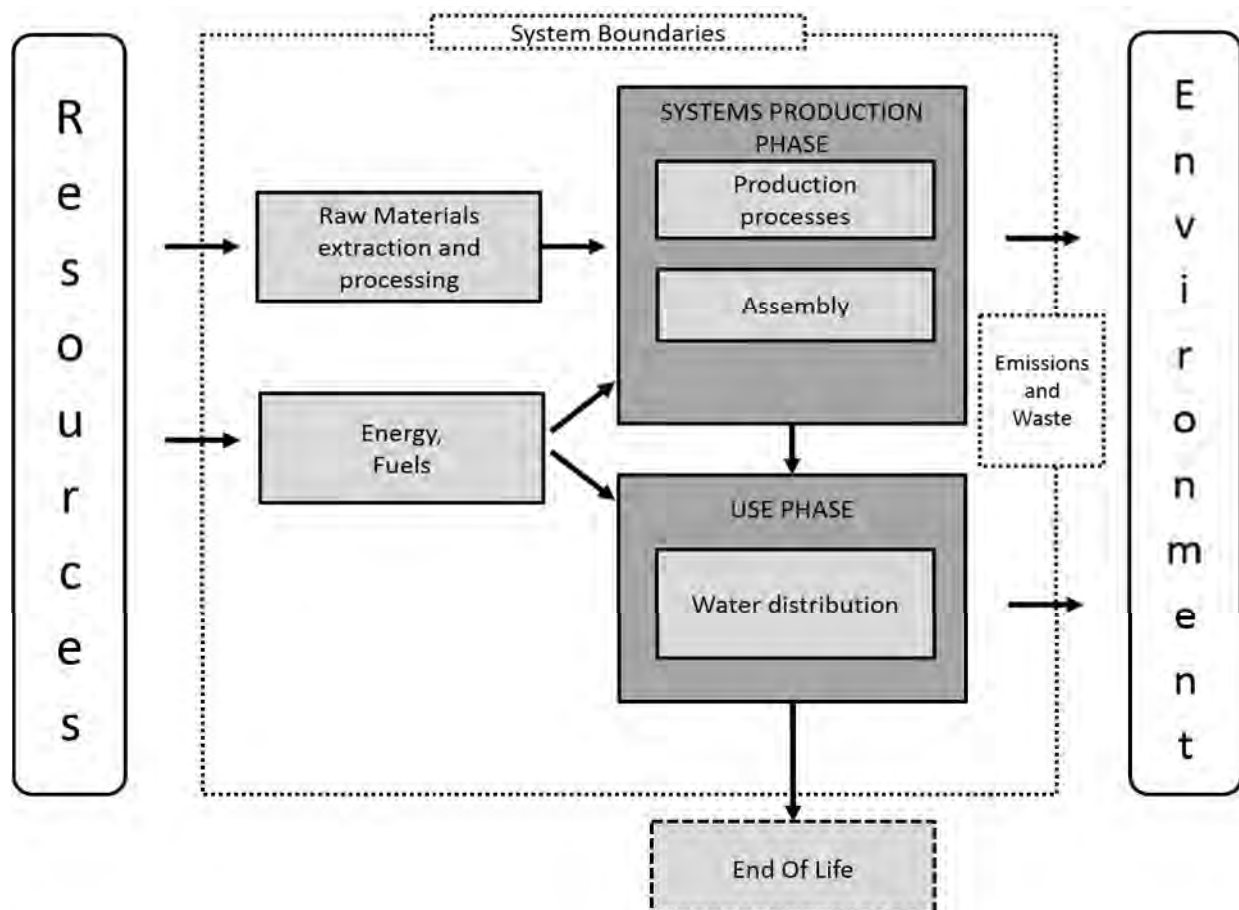


Figure 3. System Boundaries.

The disposal scenario of the two irrigation systems is out of the scope of this study. This is because it has been difficult to source consistent data about the disposal of the systems once they complete their economic life.

As previously underlined, the goal of the study is to compare the environmental impact of a sprinkling irrigation machine and dripline system, considering the impact category of Global warming Potential, measured in Kg CO₂ eq. The functional unit chosen, to which all results have been reported, is the m³ of water distributed to the field.

Description of irrigation systems

a) Hose reel machine equipped with a travelling rain gun.

The hose reel machine has four main components: a large reel mounted on a four-wheel cart, a large semi-rigid polyethylene hose that is wound on the reel, a gun cart and a large volume gun-type sprinkler mounted on the gun cart. The gun cart is trailed at the end of a travel line along with the rigid hose. During operation, the hose pulls the gun cart back as the hose is wound onto the hose reel. The hose reel is powered by a water turbine. The machine chosen for comparison is equipped with a 400m length hose of 125 mm of external diameter. The gun cart is equipped with a big gun sprinkler, named Explorer, with a 30 mm Ø snorkel nozzle.

b) Dripline system:

Drip irrigation involves dripping water onto the soil at very low rates from a system of small diameter plastic pipes fitted with outlets called emitters or drippers. Pipes are usually grounded to apply water close to plant roots. The dripline system chosen for comparison is flat emitter dripline, pitch 30 cm, in two versions:

- 16 mm external diameter, 8 mills thickness
- 22 mm external diameter, 10 mills thickness

Life Cycle Inventories

Life Cycle inventories (LCI) of the analyzed systems are presented below. The LCI are lists of the flows from and to the systems, such as inputs of water, energy, and raw materials and emissions or waste release to air, land, and water. For each of the analyzed systems the inventory has been divided in two sections, relating to production and use phase, to make easier a reallocation of their impacts to the chosen functional unit. The Members of AMIS, Italian association of self-propelled irrigation machine producer, have provided data regarding the production phase of hose reel machines and rain guns. Data on dripline have been gathered from technical sheets and catalogues of producers.

Production Phase

Following the LCI for production phase of the two systems. First the LCI of the 125/400 hose reel machine is presented in Table 1, then sprinkler cart and Explorer gun sprinkler in table 2 and table 3, and lastly the LCI of the dripline system in table 4.

Table 1. LCI hose reel production phase.

LCI Hose reel 124/400		
Material/Process	Unit	Quantity
Steel (low alloyed)	Kg	1834,44
Paints	Kg	18,872
ABS (Acrylonitrile butadiene styrene)	Kg	6,652
Aluminum Milling-turning	Km removed all.	1,75
Aluminum	Kg	28
Cast Iron	Kg	32,2
Cast Iron Milling-Turning	Km removed iron	1,38
Plastic pipes Extrusion	Kg ext. material	1370
Steel sheet rolling	Kg rolled material	314,2
Aluminum extrusion	Kg ext. material	0,24
Laser cut	seconds	993
Lubricant oil	Kg	11,48
Polyethylene	Kg	1370
Steel bar rolling	Kg rolled material	690
Milling-turning steel	Kg removed material	7,785
Synthetic rubber	Kg	1,29
Injection moulding	Kg moulded material	7,942
Arc welding	m	62,39
Zinc coating	Kg coated material	1015

Table 2. LCI gun cart production phase

LCI gun cart		
Material/Process	Unit	Quantity
Steel (low alloyed)	Kg	245
Synthetic rubber	Kg	35,2
Injection moulding	Kg moulded material	35,2
Paints	Kg	0,807
Laser cut	seconds	100
Arc Welding	m	8

Table 3. LCI Explorer production phase

LCi Explorer sprinkler		
Material/Process	Unit	Quantity
Aluminum	Kg	5,5
Chromium steel	Kg	2,6
Milling Turning	Kg removed material	7,785
Polyethylene	Kg	1,43
Injection moulding	Kg moulded material	1,43
Brass	Kg	0,4
ABS	Kg	0,409
Calendering	Kg treated material	0,409
Heat (from Natural Gas)	MJ	226

Table 4. LCI Dripline production phase

LCI Dripline System (per hectare)			
Material/Process	Unit	Quantity	
		Ø 16	Ø 22
Polietilene	Kg	87,1	120
Injection moulding and extrusion	Kg treated material	87,1	120

Use Phase

Life Cycle inventories regarding the use phase have been modelled considering average working conditions for the two systems (Table 4). As previously mentioned, impact of use phase is mainly due to the production and combustion of diesel burned in combustion engine, which generate the power needed to feed with pressured water the irrigation systems.

Table 5. Systems working conditions

Working Conditions			
	Unit	Hose Reel	Dripline
Economic life	Years	15	1
Seasona Irrigation volumes	m3/ha	2500	2500
Max irrigable area	ha	35	1
Pressure at pump	m.w.c	70	3
Working pressure Pressure (output)	m.w.c	50	15
Flow rate	l/min	1260	363

The consumption of diesel has been calculated with the following formulas:

$$C = W * CS$$

C = Diesel consumption of the pump (g/h);

W = Power absorbed by the pump (kW)

CS = Specific consumption of the endothermic engine (g/kWh)

And

$$W = \gamma * Q * H / 102 * \eta$$

γ = Specific weight of water at 4 °C in Kg/m³

Q = pump flow rate in m³/s;

H = Hydraulic head in m H₂O;

η = Pump efficiency (70%).

Following the LCI of the use phase:

Table 6. LCI Use phase (Diesel Consumption)

LCI Use Phase			
		Hose reel	Dripline
Hourly consumption	l/h	4,26	0,84
Seasonal consumption	l/ha	125,99	101,64

The CF has been assessed multiplying inventory flows by the emission factor corresponding to that activity, material or process. Emission factors are from the EcoInvent database version 3 of the Swiss Centre for Life Cycle assessment. The LCIs have been analyzed with the software Simapro (8.0.2, pre-sustainability-2014, UK).

Results

The results of the inventories analysis is presented below, starting with the production phase, use phase, and finishing with the allocation impacts to the Functional Unit. CF has been assessed using the IPCC 2013 GWP 100a method.

Impact of production phase

The total impact due to the production of the Hose Reel system is 7520 Kg CO₂ eq. Figure 2 presents the contribution of the components to system impact.

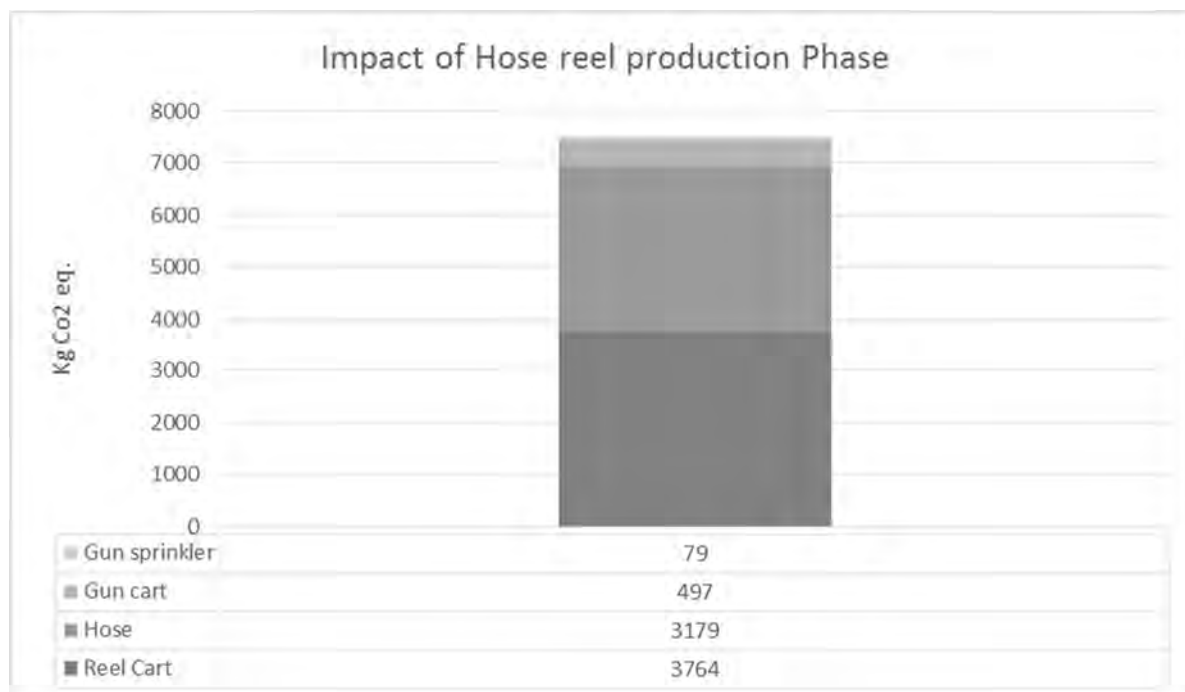


Figure 4. Impact of production phase of the hose reel system

The reel cart is the component with a higher contribution to the system CF (50%), followed by the hose (42%).

As previously underlined, two dripline models have been assessed in this study. Impact has been evaluated considering the quantity of material necessary to cover a hectare of cultivated surface. Dripline diameter is usually chosen in function of filed length and therefore two models of dripline have been analyzed to partially assess this variability. Impacts due to production phase of 16 mm Ø and 22 mm Ø dripline are presented in table 3.

Table 7. Impact of production phase of the dripline system

Impact dripline production (per ha)		
Materials/Processes	Kg CO2 eq.	
	Ø 16	Ø 22
Polyethylene	192,67	266,4
Injection moulding and extrusion	30,15	41,68
TOTAL	222,82	308,08

Impact of use phase

CF of use phase is mainly due to diesel production process and combustion, which is necessary to power the hydraulic pumps for feeding the systems with water at a required pressure and flow rate. Following the impact of use phase, due to the season volume distributed on 1 hectare.

Table 8. Impact of use phase, per m3 of distributed water

Impact Use phase (per ha)	
System	Kg CO2 eq.
Hose reel	401
Dripline	324

CF of the systems

The functional unit of this study is the m3 of distributed water, therefore all the impact of production and use phases have been reallocated, based on system lifetime, seasonal irrigation capacity and seasonal distributed water. The main difference between the two systems is that economic life of Hose reel machines is 15 years while dripline are replaced annually. Moreover, Horse reel operational capability is defined by machine characteristics (hose diameter and length), while dripline systems are dimensionless (virtually there are no limitations on irrigable surfaces). The Hose system analyzed in this study is capable of irrigating 35 hectare seasonally, 525 during its economic life. Dripline refers to the quantity of pipes and dripper necessary to cover a hectare of surface. Both the systems distribute 2500 m3 of water per hectare seasonally. The following chart presents the CF footprint of the two systems, regarding the m3 of distributed water.

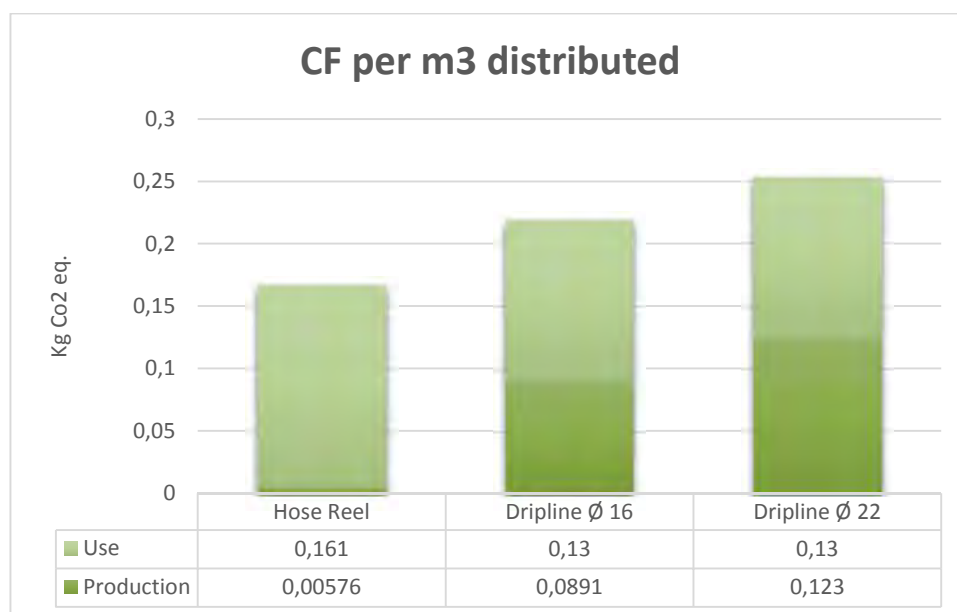


Figure 5. Carbon footprint of the analyze systems, FU=1m3 of distributed water

The 22mm diameter dripline is the system which shows the higher impact, with 0,253 Kg CO2 eq. per m3 of distributed water, followed by 16mm dripline with 0,219 Kg CO2 eq. per m3 and the Hose Reel with 0.167 Kg CO2 eq. per m3. Impact of hose reel production phase has little contribution to the system overall CF (about 3%). On the contrary, production of Dripline systems contributes for 41% of CF for the 16 mm and for 48% for the 22 mm. This is because dripline systems used to irrigate open field cultivations are substituted annually.

Conclusions

The analysis performed in this study shows that the dripline system has the higher carbon footprint referring greenhouse gas emission to 1m³ of irrigation water . This is because dripline are disposable systems and an assessment performed on the entire life cycle of the systems shows that this has an important influence on environment impact . However, this study assesses only one impact indicator (CF) and do not consider possible differences in plant water use related to the irrigation system. In any case, other factors should be assessed when performing analysis on irrigation sustainability such as soil condition and composition, culture, climate zone and weather. The experience and competence of whom operate the systems should also be considered, although it is difficult to measure.

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An olive pruning machine for marginal areas

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Abstract

In many sub-Apennine areas of central Italy, climatic and soil difficulties caused the spread of the olive trees more than other crops, thanks to their ability to adapt to those conditions and thanks to the help of dry stone walls.

In this way in the past was possible to have many olive lands, today in those lands there are marginal olive groves. In fact in such areas, the maintenance of olive groves is expensive and difficult, especially regarding the practice of pruning. In the absence of such pruning, olive trees would return to being new woodland. Pruning also requires workers with specific skills to maintain the right shape of trees. Such labor is increasingly unavailable.

Due to the large gradients, which make difficult and dangerous the machines use, subject to instability and tipping, with consequent risks for the operator, the mechanization is not able to improve the situation totally. In fact in many areas olive groves are neglected, resulting no gains for the farms and also lack of those areas maintenance. It is also necessary to consider the known environmental hazards related.

The aim of the research is to assemble a new machine with pruning bar provided with rotary discs, and totally operated by a remote control. The driver is placed on the ground some meters far from the machine to reduce the risk to his life, in the case of the machine rolling over.

To evaluate the efficiency of the machine some pruning tests will be done in marginal areas.

Keywords: Pruning Machine, Steep Ground, Remote Control

Introduction

The olive growing in central Italy is not only a productive sector also one of the main naturalistic resources, which contributes to the hydro-geological protection of the ground, to the conservation of old olive varieties and to the territory defence, through the presence of man and farms often directed to the tourist reception.

The olive tree was the only plant that could adapt in areas with soil and climatic difficulties, thanks to its hardiness and the help of dry stone walls. Thanks to this olive tree attitude, many lands were cultivated in the past. Today on those same marginal lands there is an olive growing difficult to manage, even from an economic point of view.

In fact in such areas, the olive growing is expensive and difficult, especially in regards to the practice of pruning. In the absence of such pruning olive groves will return a new woodland. Labour for pruning, which must have specific skills, is difficult to find.

Moreover, the mechanization is not always able to improve the situation, because of the considerable gradients, which make difficult and dangerous the use of the machines, subject to phenomena of instability and tipping. In fact in these areas it is clear the neglect of the crop, the lack of income for farms, but also the lack of the lands maintenance with the known environmental hazards related. It is necessary to prepare actions that will make cheaper olive cultivation in marginal areas, taking into account the possibilities offered by mechanization and collective machines utilization. It is important to consider that the

machines use in the steep grounds, that often are wet because of the presence of grass cover, also produces issues related to operator safety against the risk of tipping of the machines. Moreover the farmers are not young and they have a low level of training and information on the risks present in the workplace.

Aim of the research is to provide a tracked machine, equipped with bar pruning and able to be operated by the driver, placed on the ground, thanks to a remote control. The driver has less risk in the event of tipping of machine.

Materials and methods

Two different elements form the utilized pruning machine. A tracked tractor and a pruning bar were assembled and tested. The tracked tractor is a remote-controlled machine, with hydrostatic transmission. Its peculiar design concept, the low baricenter, the track edges shaped to operate in very bumpy areas still maintaining the greatest traction, special engine oil pan which allows the prolonged use of the machine, in declivity conditions in any direction, up to 50°. It is equipped with a diesel 58 kW engine. The machine sizes are: 2,525 meters in length, 1,565 meters in height and extensible width from 1,330 meters to 2,030 meters. The machine weight is about 1000 kg. It is possible to apply many equipments in the front part, to make the machine as multifunction (fig. 1). The remote control has 150 meters range. Two joysticks grant the control of the steering movement and the control of the pruning bar (fig. 2). The market offers two types of pruning bar with rotary discs or with blades. The first is most suitable for cutting wooden elements of large diameter and therefore is able to work on plants not pruned for some years. The first one was chosen. A vertical bar with 8 cutting disks, 2 meters in length, carries out the vertical cut. It has the possibility to incline of about 30°. A horizontal bar of 6 cutting disks and 1,5 meters in length is assembled on the vertical one. Its inclination is from 0° to 90°. To help the removal of pruning from the bars the rotary disks have a special shape (fig. 3). All bars movements are continuous and performed by remote control. Thanks to the extension of the pillar that supports the two bars, the cutting height arrives up to 4,7 meters (fig. 4).

After the machine assembly, some tests were done in an olive grove of about 10.000 m² and of 277 trees, placed on a grid of 6 meters side. The plants were bred as cone-shaped pot. Two years ago the last pruning was done. The ground slope was about 40% (fig. 5).

After the mechanical pruning around the plant, the final work inside the canopy was done manually and the timing for this operation was detected.



Figure 1. The machine assembled and utilized in the tests.



Figure 2. The remote-control.



Figure 3. The particular shape of rotary disks.



Figure 4. The machine at work.



Figure 5. The olive grove.

Results

The machine did not malfunction. Its movement under trees was flowing also on the curves at the end of the field. The forward speed has been about 0.27 m/s and a total time of about 8 hours per hectare. The cut was achieved both on the four sides of the plant (hedging) that in the high part (topping).

It is necessary to report that the driver at the end of day's work was tired. It is advisable to plan some shifts. The objective to have a secure job for driver was achieved. He always worked far from the machine.

The next manual finishing took about 4 minutes per plant for a total of about 18 hours and 30 minutes. The obtained data are smaller than the pruning operation carried out totally manually, which requires about 70 hours per hectare.

The manual labor costs are of 20 euros per hour, while for the machine operation are necessary 90 euros per hour. Therefore the use of the machine and the next manual finishing cost 1.090,00 euros per hectare, while the manual pruning costs are 1.400,00 per hectare.

Conclusions

Mechanical pruning is not new, because several experiences of mechanical pruning in Italy were done, with machines connected to the tractor. The novelty lies in having created a machine with driver on the ground. In fact this position, especially in sloping ground reduces the risks for the operator. In addition, the operator on the ground is not subject to mechanical vibration.

The remote controlled machine is a tool, on which can be mounted other machines for the olive growing, such as an apparatus for treatments, for the shredding of pruning and for the collection. The height of the machine is very low and allows it to move close to the trunk of the plant, for example to perform the shredding of pruning, operation impossible with traditional tractors.

The savings of more than 300,00 euros per hectare is definitely an incentive to the maintenance of olive groves present in marginal areas with steep slopes.

Acknowledgements

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TOPIC 4

“Noise, Vibration, Dust, Endotoxin, Microorganism”

Field and static tests to assess the drift of abrasion dust of dressed maize seeds

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Abstract

Pneumatic precision drills employed in maize (*Zea mays* L.) sowing are responsible for the emission in the atmosphere of abrasion dust containing active ingredient (a.i.). In recent years, several insecticides (especially neonicotinoids) employed for maize seed dressing have been claimed to cause mortality and sub-lethal effects to honey bee (*Apis mellifera* L.). Moreover, the emitted particulate matter can be inhaled by the operators during the seed loading and manipulation and during the sowing. This work aims at assessing the amounts of a.i. emitted by precision drills during sowing operations. We carried out static tests, simulating the sowing at fixed point, and real sowings in field. To collect a.i. residues, we used passive samplers (Petri dishes) for the residues at ground level. We employed maize seeds treated with three neonicotinoids insecticides (clothianidin, imidacloprid and thiamethoxam) and with fipronil. The results show the amounts of dust emitted by a pneumatic precision drill during the sowing of maize. Moreover, a method to predict the theoretical dust drift in the field, starting from the results of the static test, is provided.

Keywords: Pesticides, Airborne Particulate, Neonicotinoids, Honey Bee, Seed Coating.

Introduction

Pneumatic precision drills used in maize (*Zea mays* L.) sowing can release amounts of dust coming from the abrasion of dressed seed. In recent years, scientists and beekeepers ascertained a relationship between mortality and decline of honey bees and the spring sowing of maize (*Zea mays* L.) seeds dressed with neonicotinoid insecticides (imidacloprid, thiamethoxam, clothianidin) and fipronil (Greatti *et al.*, 2006; Tremolada *et al.*, 2010; Pistorius *et al.*, 2010; Tapparo *et al.*, 2012; Nuytens *et al.*, 2013). Moreover, the emitted particulate matter can be inhaled by the operators during the seed loading and manipulation and during the sowing (Biocca *et al.*, 2013; Biocca *et al.*, 2014).

Some test methods have been developed to classify the drills according to their capability to release abrasion dust during the sowing (Rautmann *et al.*, 2009; Manzone *et al.*, 2014) but it is still lacking a test method recognized as international standard. We have developed a method based on static tests to obtain reproducible test conditions and comparable results. The method is based on the simulation of the sowing of maize dressed seed under artificial wind conditions. The method was used for assessing the efficiency of drift reduction devices applied to the seeder in comparison with the emissions of the conventional machine (i.e., the same drill without the devices) (Apenet, 2011; Biocca *et al.*,

2011). Through a data processing method of the results provided by the static tests, it is possible to predict the dispersion of active ingredients (a.i.) that would occur in the field under similar conditions.

This paper provides evidence of the correspondence between the amount of predicted drift at ground level during static tests and the measured residues during field trials.

Methods

Seed

The trials were carried out using commercial maize seed (Pioneer Hy-Bred PR32G44) dressed with four insecticides (Gaucho™, a.i.: imidacloprid; Poncho™, a.i.: clothianidin; Cruiser™, a.i.: thiamethoxam, Regent™, a.i.: fipronil) and a fungicide (Celest™, a.i.: fludioxonil and metalaxyl). According to the manufacturers, the application doses of a.i. were respectively equal to 1.00 mg seed⁻¹ for imidacloprid, 1.25 mg seed⁻¹ for clothianidin, 0.60 mg seed⁻¹ for thiamethoxam and 0.50 mg seed⁻¹ for fipronil.

Drills

A six-row precision pneumatic drill, Gaspardo mod. “Magica”, was employed, with and without air deflectors applied at the fan opening. Deflectors made up of four pipes that redirect the air stream from the fan exit towards the soil, inside the furrows opened for seed deposition, reducing the dust drift. The device can be removed, restoring the “conventional drill” conditions and allowing the comparison between the conventional and modified machine.

Test system at fixed point

The static tests were carried out in the workshop’s porch of CRA-ING, a site protected by external influences (Fig. 1), as described in Biocca *et al.* (2011). In the test site, artificial wind conditions were produced by means of the axial fan (0.735 m diameter) of an orchard sprayer (Nobili Geo 75-600 T) powered by a 60 kW tractor. The air flow produced under these conditions was 22,900 m³ h⁻¹ (fan speed of 2160 rpm). Preliminary tests showed the repeatability and the constancy of wind conditions (speed and direction). The average wind speeds in the sampling site were 1.4 m·s⁻¹ at 0.5 m from the soil (min 0.0, max 2.6 m·s⁻¹) and 1.8 m·s⁻¹ at 2.0 m from the soil (min 1.6, max 2.5 m·s⁻¹).

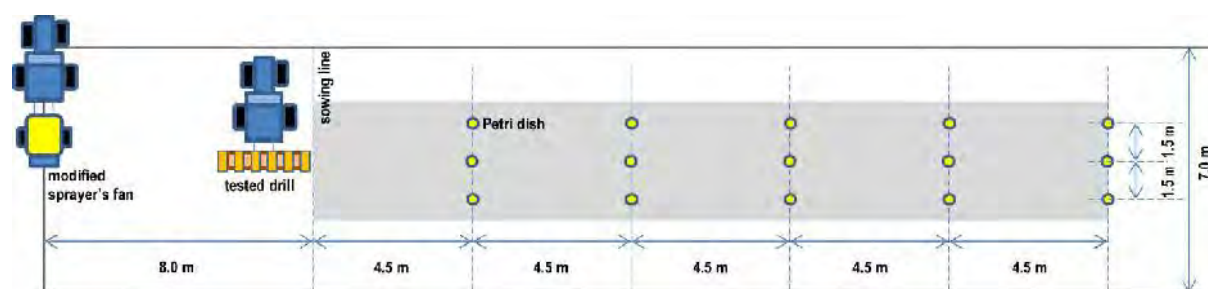


Figure 1. Layout of the static tests area

The drill, suitably placed in the test area, operated the seed distribution by means of an electric engine connected to the driving wheel through a gear-reducer. An inverter (OMRON Varispeed V7) allowed adjustment of the speed of the electric engine and, consequently, of the peripheral speed of the driving wheel, on the desired value of 1.67 m·s⁻¹.

In the test site, which resembled a wind tunnel, we have delimited a 22.5 m long sampling area, downwind with respect to the drill position. Along the sampling area, five series of Petri dishes, spaced 4.5 m, were placed; each series consisted of three Petri dishes spaced 1.5 m; therefore, a grid of 15 sampling points was arranged (Fig. 1). Before each test, the Petri dishes were filled with a 50% acetonitrile-water solution.

The test consisted in the sowing of one sack of seed (25,000 seeds), corresponding to a virtual sowed surface of 3,333 m². Each trial was replicated three times for each investigated a.i.

Field tests

The trials were carried out in the experimental farm of CRA-ING (circa 42°5'51.26" N; 12°37'3.52" E; 24 m a.s.l.). To operate at the same seed density of 75,000 seed ha⁻¹, the drill settings were the same as in the static tests. During the trials, the main micrometeorological parameters were monitored.

The tests were carried out sowing 3 ha rectangular plots (~ 140 x 215 m). The evaluation of the dust deposition at ground level was made using the same types of samplers as for the tests at fixed point (Petri dishes with 50% acetonitrile/water solution). The sampling area corresponded to a 20 m wide belt around the field perimeter. The dust ground deposition was observed on all plot sides (North, South, East and West) with the aim of capturing the settling dust at ground level independent of the possible changes in wind direction during the trials. A series of three Petri dishes spaced 1.5 m apart were placed on each side at 5, 10 and 20 m from the field edge; hence, a total of 36 sampling points was obtained (Fig. 2). One field trial was conducted for each investigated a.i.

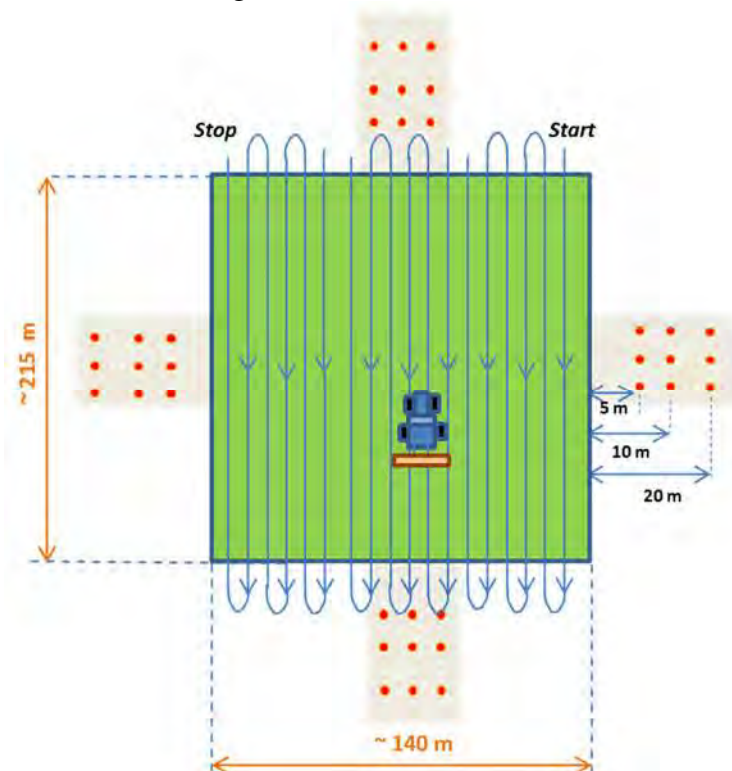


Figure 2. Layout of field trials, showing position of samplers (Petri dishes) (not in scale).

Determination of active ingredients

The determination of active ingredients in the samplers was carried out at CRA-PAV, by means of HPLC coupled to a MSD (Mass Spectrometry Detector) operating with an ES+ (Electrospray Ionisation Interface, positive mode), as described in Biocca *et al.* (2011).

Data processing for the assessment of the theoretical a.i. concentrations in the field

The values of a.i. concentrations obtained at ground level during the trials at the fixed point were elaborated to provide the theoretical a.i. concentration pattern that would occur in the field. The data processing to pass from fixed point data to virtual field data entails the following steps:

- Transforming the values of $\mu\text{g}\cdot\text{plate}^{-1}$ in $\mu\text{g}\cdot\text{m}^{-2}$;
- Calculating the area of the virtual plot sowed with the seed quantity employed in the static test;
- Finding the number of passages necessary to sow the virtual plot;
- Recalculating the concentration corresponding to a single passage;
- Obtaining the drift curve.

From the a.i. content in the Petri dishes ($\mu\text{g}\cdot\text{plate}^{-1}$) and the virtual number of Petri dishes (105.2 m^{-2}) we obtained the a.i. concentration per surface unit in $\mu\text{g m}^{-2}$. Considering the virtual forward speed, the amount of seed used and the drill's working width, the virtual sowed area has a surface of $3,333\text{ m}^2$, as indicated above. Such a plot sowed without turns would be 740.8 m long and 4.5 m wide. As previously mentioned, five series of three Petri dishes were placed on the sampling area. To obtain a sampling distance from the initial sowing line equal to the working width (or multiples of it), the five series of three Petri dishes were spaced 4.5 m. Moreover, the distance between two contiguous Petri dishes of the same series was 1.5 m, which determined a reference width of the sampling area of 4.5 m, parallel to the sowing direction. The ratio between the above mentioned distance of 740.8 m and the 4.5 m width of the sampling area provides the theoretical number of drill passages, i.e., 164.6, along the sampling area.

As a consequence, the a.i. concentration after a single passage can be calculated by dividing the concentration observed after the test (average of three values) by the number of passages (164.6). This method provides an estimation of the concentration of the a.i. ($\mu\text{g}\cdot\text{m}^{-2}$) after one passage at the five sampling distances (4.5, 9.0, 13.5, 18.0, 22.5 m). Under field conditions, the drill distance from the initial sowing line (assumed as zero) and from the Petri dishes of a hypothetic sampling area would increase by 4.5 m (working width) after each passage. For example, after three passages of the drill, the Petri dishes at 4.5 m from the initial sowing line would receive an a.i. amount resulting from the sum of the concentration calculated at 4.5 m (first passage), 9 m (second passage) and 13.5 m (third passage). For n passages of the drill, the theoretical concentrations that would occur in the field can be calculated by means of a matrix obtained by repeating the calculated series of values n times, taking care to displace the series of one place (4.5 m distance) after each passage. Because there are five sampling distances in the static tests, the maximum number of passages used to generate the matrix would be five ($n = 5$). To achieve the result for $n > 5$, the exponential regressions of the series of five concentration values as a function of the distance were calculated for both the conventional and modified drill. The equations provided by the process were used to calculate the concentration for distances greater than 22.5 m from the initial sowing line.

We considered a distance of 72 m ($n = 16$) as the maximum distance reachable by the drift from the first row of samplers. This distance corresponded to approximately half the

width of the field. The resulting matrix provided the global theoretical concentrations at ground level ($\mu\text{g}\cdot\text{m}^{-2}$) at distances ranging from 4.5 m to 72 m from the initial sowing line. The obtained values were then compared with the data measured in the field. The statistical analyses were computed with the software R (R Core Team, 2013).

Results

Figure 3 summarizes the results of the depositions at ground as the average of all active ingredients ($\mu\text{g}\cdot\text{m}^{-2}$), both indoors (static) and in the field tests. For each distance, the samples were composed by 36 values for the ground deposition at fixed point and 48 values for the ground deposition in the field.

In the field and static tests, the use of deflectors caused similar values of dust emission reduction (Table1).

Figure 4 shows the virtual pattern of dust drift (at ground level) resulting from the data at the fixed point processed as described above. The curves show the predicted dust deposition at ground level from 4.5 m to 72 m from the drill, in the hypothesis of 16 drill passages.

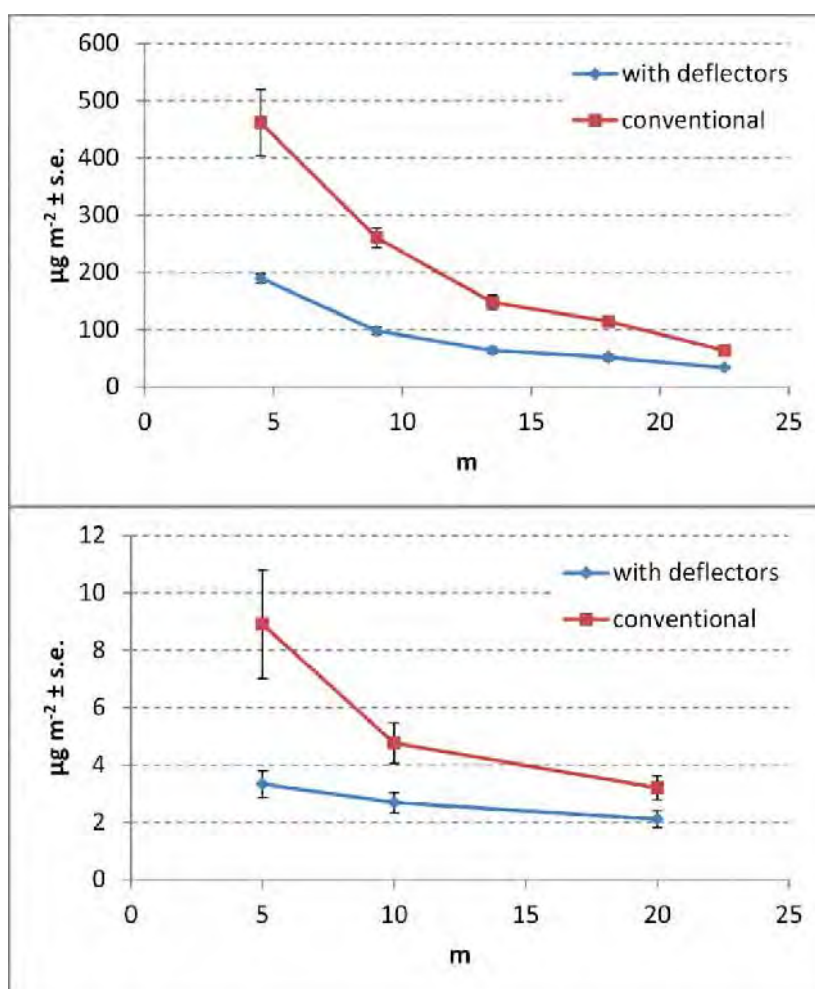


Figure 3. Drift average residues of the four a.i. at ground level ($\mu\text{g m}^{-2} \pm \text{s.e.}$) in fixed point tests (up) and in the field (down). The amounts of a.i. in the static tests are very high because the dust dispersed during the sowing is concentrated in a small sampling area.

Table 1. Average percentages of reduction of dust emission caused by the deflectors during field and static tests.

	m.u.	clothianidin	fipronil	imidacloprid	thiamethoxam	average
Field	%	33.9	43.1	69.4	33.3	48.1
Fixed point	%	47.0	54.0	74.6	51.6	56.0

The curves of figure 4 were utilized to obtain the values at 5, 10 and 20 m (i.e., the sampling distances adopted in the field tests) to compare them with the corresponding values actually observed in the field. Then, linear regressions between the field (measured) and indoor (predicted) values were computed. The regressions were performed for all a.i. (n=48, 24 pairs of values). The results of the regression are reported in figure 5 that also shows the adjusted R^2 values, the formula of linear regressions and the result of probability tests (p value).

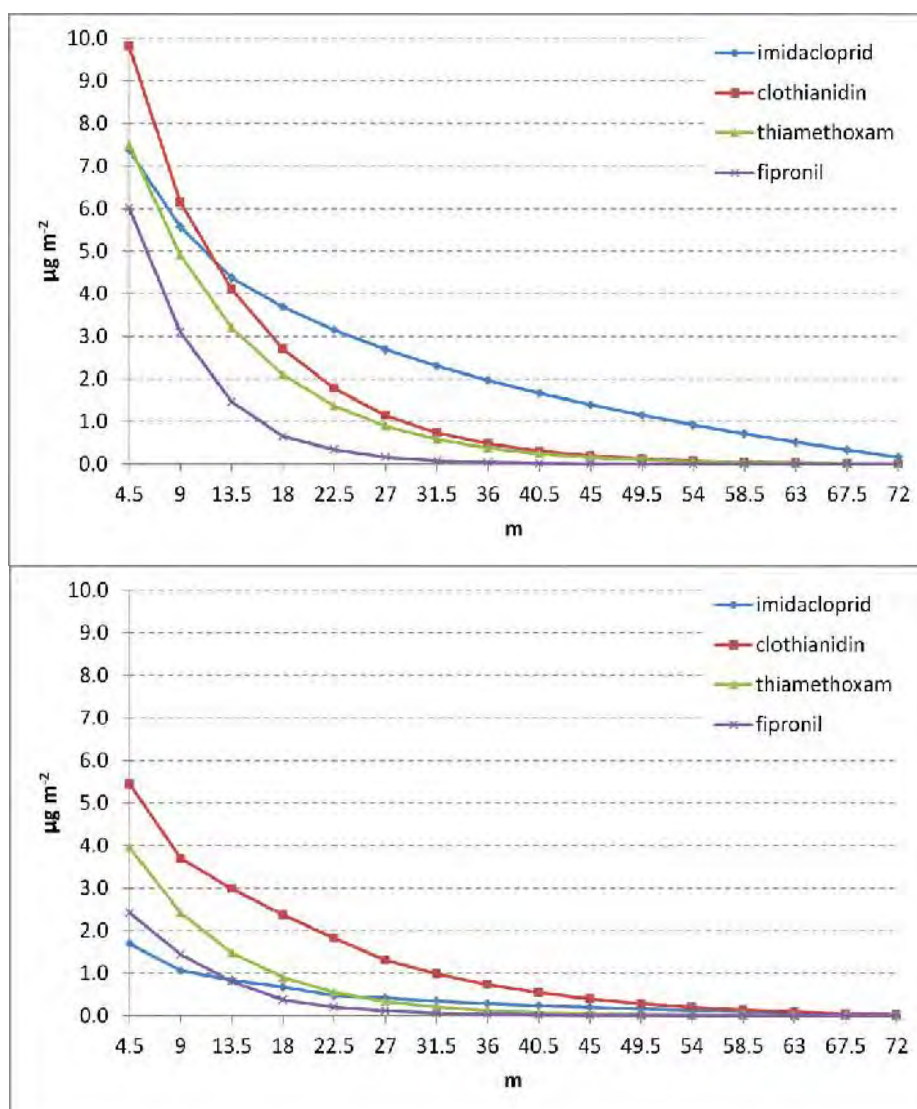


Figure 4. Prevision of the pattern of dust deposition from the results of static tests: conventional drill (up); drill with deflectors (down).

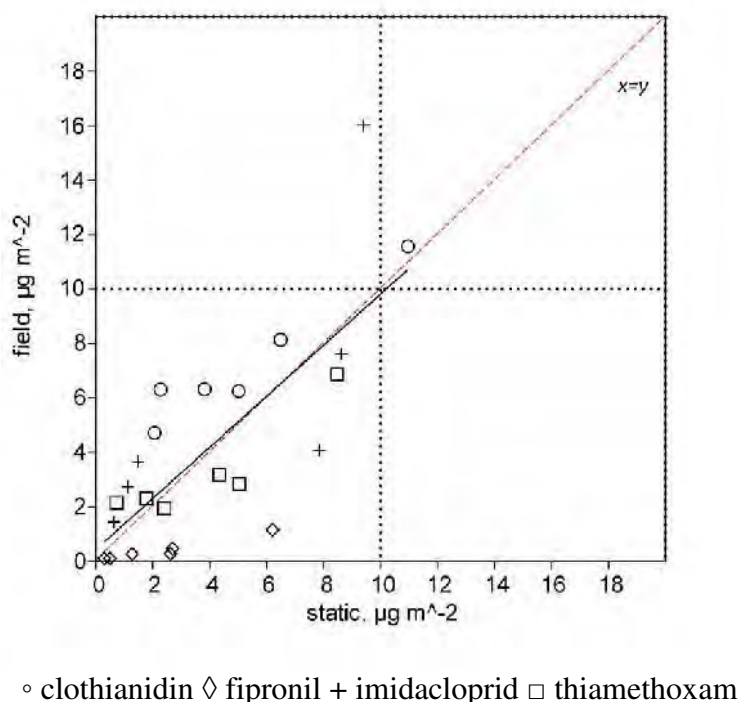


Figure 5. Linear regression (black line) between the values of the ground residues in the static and field tests. The red line means identity ($x=y$). The regression for all active ingredients (up) was: $y = 0.9397x + 0.4231$; adjusted R^2 : 0.56; p value = $1.408 \cdot 10^{-5}$

The prevision based on the static test data underestimates the measured field data for clothianidin and imidacloprid (differences between field and prevision average values: $2.11 \mu\text{g}\cdot\text{m}^{-2}$ for clothianidin; $1.06 \mu\text{g}\cdot\text{m}^{-2}$ for imidacloprid). It can be noted that the result for imidacloprid is strongly affected by one single high value observed at 5 m in field tests. As for fipronil and thiamethoxam, an overestimation of data (difference between field and prevision average values is $-1.88 \mu\text{g}\cdot\text{m}^{-2}$ for fipronil and $-0.58 \mu\text{g}\cdot\text{m}^{-2}$ for thiamethoxam) was observed. As for the results of the linear regression, the field and static (indoor) data are significantly correlated (p value = 1.408×10^{-5}) with a R^2 of 0.58.

Discussion

This paper aimed at verifying the correspondence between the predicted field amounts of dust drift calculated on the basis of the results of static tests and the residues actually measured during field trials. In spite of the variability of environmental conditions, primarily wind speed and direction, that can strongly affect the dust deposition during field tests, the values ($\mu\text{g}\cdot\text{m}^{-2}$) of the two series (predictions and measurements) are of the same order of magnitude, as are the reductions of the depositions of a.i. caused by the use of deflectors, both in the static and field tests. The correspondence between the two series of data is confirmed by the linear regression, applied to all the active ingredients, that yielded significant results.

In conclusion, the method based on tests at a fixed point with side wind artificially provided, seems reliable, reproducible and accurate. It appears suitable for testing the predisposition of sowing machinery to spread abrasion dust, as well as the contained chemicals and to verify the effectiveness of the devices aimed at reducing dust emissions. The method, through a proper data processing, also seems capable to provide a good estimation of

the distribution of a.i. at ground level that would occur in the field, under the same conditions of wind, travel speed and sowing density.

However, to employ the method as a standard method to evaluate drill performance, some practical aspects need to be improved. For example, the analytical phase should be simplified and the risk of exposure reduced. Such objectives could be achieved by using seed dressed with a non-toxic and an easily-detectable tracer. An essential point is that the seed should be dressed similarly to commercial seed to have results referable to normal operative conditions.

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Whole-Body Vibration exposure.

An ergonomic evaluation of the effects of an active suspended cab fitted on an agricultural telehandler

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Abstract

Exposure to whole body vibration (WBV) is one of the most important risk factors for musculoskeletal disorders (MSDs). Agricultural machinery operators are particularly at risk and it is therefore important to minimize the transmission of harmful vibrations to the driver as much as possible. Telescopic handlers are self-propelled vehicles very versatile used on different terrains and for different operations. Despite their diffusion few studies investigated their vibrational safety and comfort. The objective of the study was to investigate whether an active cab suspension system fitted on a telehandler was effective in reducing WBV and in improving comfort. Sixteen male healthy professional operators drove a telehandler on a 100 m ISO 5008 smooth track at two different speeds (5 and 12 kph) with activated and deactivated cab suspension system. Adopting an ergonomic approach, different aspects of the human-machine interaction were analyzed: 1) WBV measurements, 2) subjective ratings of general comfort and local body discomfort, and 3) anthropometric characteristics of the users. The suspension system was effective in reducing WBV and in improving comfort, especially for individuals with higher stature, body mass and Body Mass Index (BMI). Some neck/shoulder and lumbar complaints seems to remain, even when the system was activated. Results suggest that the operators, given their wide range of physical variability, may need more adjustable or customizable WBV reduction systems.

Keywords: Ergonomics, Comfort, WBV, Telehandler, ISO 5008

Introduction

Exposure to whole body vibration (WBV) has been identified as one of the most important risk factors for musculoskeletal disorders (MSDs) (Kittusamy 2002; Lyons 2002; Osborne et al. 2012; Zimmermann, Cook, & Rosecrance 1997), having severe effects on low-back pain, neck-shoulder disorders, early degeneration of the spine and herniated discs (Bovenzi & Zadini 1992; Griffin 1990; Kittusamy 2002, 2003; Kittusamy & Buchholz 2004). Some anthropometric characteristics of the users, such as stature, body mass and Body Mass Index (BMI), seem also to play an important role in enhancing (Bovenzi et al. 2006; Milosavljevic, Mani, Ribeiro, Vasiljev, & Rehn 2012) or reducing (Sadeghi, Habibi, & Sajjadi 2012; Wang, Rakheja, & Boileau 2006) the WBV and the subsequent risk of MSDs.

MSDs are a main issue of concern in agricultural industry: in Europe, 2,070,000 out of over 40 millions occupational diseases among agricultural operators are MSDs (EU OSHA 2010). Agricultural and earth-moving machinery operators are particularly at risk because

they are usually exposed to vehicle vibrations for a long time (Mayton, Kittusamy, Ambrose, Jobes, & Legault 2008).

The awareness of the hazards related to WBV led to the development of standards and requirements regarding the exposure of workers. The development of WBV standards started in 1966 in Europe, resulting in the publication of ISO 2631 (Paschold & Sergeev 2009).

In order to comply with rules and standards and to promote operators' health, safety and comfort, many technological and design innovations have been introduced on vehicles by manufacturers during last decades (for a review, see Donati 2002 and Tiemessen, Hulshof, & Frings-Dresen 2007). Innovations range from suspended seats (Hostens, Deprez, & Ramon 2004) to correct ergonomic layout of vehicle interior (Pope, Wilder, & Magnusson 1998) and to cab suspension systems (Evers, Besselink, Teerhuis, Van der Knaap, & Nijmeijer 2009; Velmurugan, Kumaraswamidhas, & Sankaranarayanan 2012). Concerning cab suspension, different solutions have been developed, from passive systems to more recent semi-active and active ones (Fischer & Isermann 2004): active systems in particular represent an important innovation, not only for WBV control but also for the improvement of ride quality, handling and performance under different operating conditions (Ikenaga, Lewis, Campos, & Davis 2000; Wong 2001).

Active suspension system has been little investigated, in particular with regard to telescopic handler (telehandlers). These vehicles are not typically involved in user trials assessing WBV exposure, despite the fact that the telehandler is a versatile and widespread vehicle used on different off-road applications (construction, agriculture, mining, etc.) on uneven terrains and for a large number of different operations (Bertani 2014).

The objective of the present study was to investigate whether an active cab suspension system fitted on a telehandler was effective in reducing WBV and in improving comfort for the operators. The study took into consideration the anthropometric variability of users and adopted an ergonomic approach *“concerned with the understanding of the interactions among humans and other elements of a system [...]”*, which considers users' involvement essential *“in order to optimize human well-being and overall system performance”* (International Ergonomic Association 2015; see also Karwowski 2006; Goodman-Deane et al. 2008).

To characterize the effects of the cab suspension system fitted on the telehandler the following aspects of the human-machine interaction were analyzed: 1) objective measures of vibration magnitude, 2) subjective ratings of general comfort and local body discomfort, 3) anthropometric characteristics of the users.

Materials and methods

Participants

Sixteen male healthy professional telehandler drivers took part in the study. Individuals with a minimum of 5 years of driving experience on telehandlers were chosen to participate in the study. The mean age of the participants and their experience operating telehandlers were 39.4 (SD=12.2) years and 20.0 (SD=14.49) years respectively. Participants completed a brief questionnaire based on the one developed by Bovenzi et al. (2006) about their work experience and musculoskeletal disorders history. All the participants did not reported any musculoskeletal disorders and were suitable for the investigation trials.

The telehandler

The telehandler used in the study was a Merlo make, P55.9CS model. It is a 2 axles, 4 wheel drive vehicle equipped with 103 kW Diesel engine and hydrostatic transmission. The

maximum forward speed is 40 kph (25 mph). The vehicle is representative of the typical telehandler architecture adopted by most of the manufacturers: the cab, with the driving station, is on the left while the engine on the right of the vehicle median plane. The telescopic boom, in 3 sections for a maximum length of 9 m, is on the median plane of vehicle. The maximum loading mass of the telescopic boom is 5500 kg. The vehicle was fitted during the test with 19,5 LR24 tires on both axles with an inflation pressure of 400 kpa (58 psi). The vehicle was fitted with an air suspended seat (SEAT make, ACTIVO SERIES S698 model) with 100 mm suspension stroke. The telehandler was equipped with hydro-pneumatic cab suspension system. The system has been designed to reduce vibration magnitude along the vertical direction, from the buttock to the head (z-axis) of the driver. The system is covered by a Merlo patent.

Whole Body Vibration

WBV at the driver's seat interface was measured using a rubber seat pad containing an accelerometer (PCB PIEZOTRONICS ICP Model 356B41 with a sensitivity of 100 mV/g). The seat pad accelerometer was fixed on the seat cushion surface between the driver and the seat. It measured accelerations in three directions (x, y and z direction) ranging from 0.5 Hz to 1000 Hz. The signal from the accelerometers was stored on the laptop using a National Instruments data acquisition card (NI9234). Later on the data were processed using a LabView software (National Instruments, 2012).

Subjective ratings

Subjective measures were collected by a questionnaire based on the one developed by Bovenzi et al. (2006). Participants were asked to rate the comfort perceived regarding vibrations during each trial on an 11-point rating scale, ranging from 0 (no comfort at all) to 10 (extreme comfort). Then, they were asked to identify body areas experiencing discomfort and to rate (from 0=no discomfort to 4=extreme discomfort) the amount of discomfort they experienced during the trial for each body area on a body map (Corlett & Bishop 1976).

Anthropometric parameters

The stature, body mass, Body Mass Index (BMI), hip breadth and sitting height were measured for each of the participants in the study, in accordance with ISO 7250-1 (2012) guidelines regarding variable descriptions, instruments and measurement conditions.

Trials

Objective measurements were carried out while the telehandler was driven over a 100 m ISO smooth track (ISO 5008:2002). Previous studies confirmed that the use of ISO-5008 track provides a reasonable basis for comparison of the WBV to which the operator of a field wheeled-vehicle is exposed, due to the high repeatability of vibration data (Cavallo, Deboli, Paletto, & Preti, 2005; Deboli, Calvo, & Preti 2012; Scarlett, Price, Semple, & Stayner 2005). Each of the participants drove the telehandler on an ISO-smooth track in 4 different conditions:

1. Trial 1 (low, OFF): speed of 5 kph, deactivated suspension
2. Trial 2 (low, ON): speed of 5 kph, activated suspension
3. Trial 3 (high, OFF): speed of 12 kph, deactivated suspension
4. Trial 4 (high, ON): speed of 12 kph, activated suspension

Before the trials, each participant performed a training trial during which he had the possibility to adjust the seat, so, in any of the test conditions, the seat suspension travel was set with vertical adjustments for custom comfort. The fore/aft adjustment of the seat was set to fit the most comfort posture for each participant.

Data analysis

Vibration data were analyzed using LabView software and converted from the record time domain to frequency domain acceleration. The resulting data were then converted to root-mean-square (rms) acceleration. This was used to calculate the frequency weighted rms acceleration values for each of the axis (a_w). The averages of the frequency spectra in one-third octave band were computed for the four trials. The frequency spectra of the accelerations recorded at the operator's seat were then analyzed in one-third octave bands.

Regarding subjective measures, descriptive statistics were computed for each of the 4 trials for comfort ratings, body discomfort areas and perceived jolts.

A series of t-tests were computed to determine whether there were any differences between the vibration magnitude measurements and between comfort ratings with activated and deactivated suspension system at the two different speeds. Correlation between vibration measurements, subjective ratings and anthropometric parameters were then calculated.

Statistical analyses were performed using Statistical Package for Social Science 21 (SPSS software).

Results

Whole body vibration measurements

Table 1 compares the means of the accelerations measured on the three axes with activated and deactivated suspension system at the two speeds. When the suspension system was activated, there was a significant reduction of the acceleration, in particular at high speed and on the z-axis.

Table 1. Means, standard deviations and t-test results for x, y and z-axis frequency weighted rms accelerations (a_w) (m/s^2) for low and high speed, with activated and deactivated cab suspension system.

Speed	Axis	Suspension system		t	p-value
		OFF Mean (SD) (m/s^2)	ON Mean (SD) (m/s^2)		
Low	X	0.42 (0.09)	0.43 (0.08)	-1.19	.250
	Y	0.51 (0.05)	0.52 (0.05)	-3.29	.005
	Z	0.69 (0.16)	0.56 (0.11)	5.08	.000
High	X	0.74 (0.51-0.99)	0.67 (0.51-0.78)	2.48	.038
	Y	0.56 (0.49-0.69)	0.64 (0.57-0.78)	-9.81	.001
	Z	1.72 (1.43-2.28)	1.13 (0.82-1.94)	11.06	.000

Focusing in particular on z-axis, Figure 1 summarize the vibration frequency spectra in one-third octave bands on the z-axis recorded with activated and deactivated system. The series of data are the means calculated on the accelerations recorded on the 16 drivers.

As it can be seen, at low speed, the peak accelerations are in the frequency range 2-4 Hz, with a maximum at 2.5 Hz. In this frequency the cab suspension system reduced nearly 27% the accelerations transmitted from the vehicle to the operators. At high speed, the peak accelerations are in two ranges: between 2 and 4 Hz and between 4 and 20 Hz. The reduction of the acceleration when the cab suspension system was activated was limited to 22% at 2.5 Hz, in the lower range frequency, while it was substantially higher, up to approximately 50% at 4.5 Hz, in the higher range.

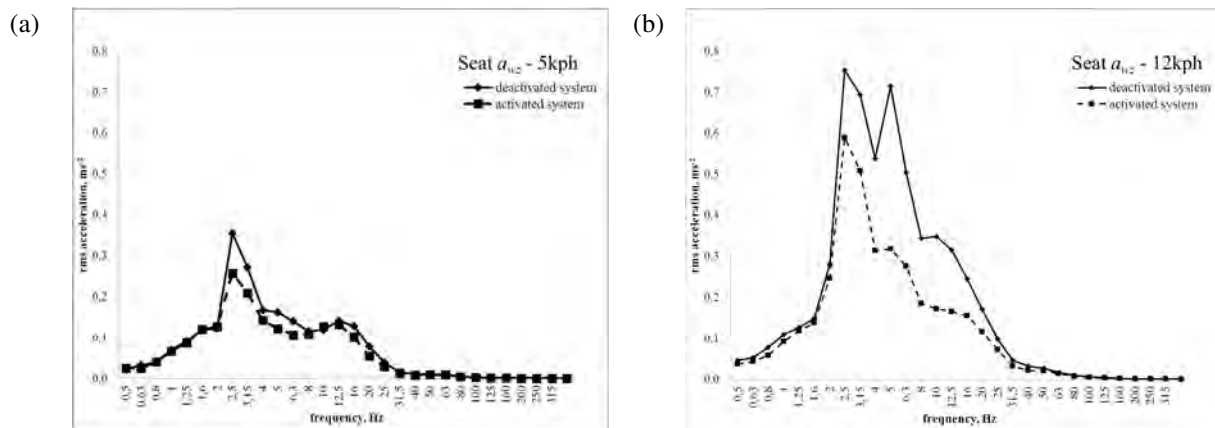


Figure 1. Frequency spectra in one-third octave bands measured on the operator's seat on z-axis at 5 kph (a) and 12 kph (b).

Subjective ratings

With regard to comfort ratings in the four trials, the t-test showed that the activation of the system resulted in a significantly higher ratings of comfort at both low and high speed (see Table 2).

Table 2. Comparisons between comfort ratings given at low and high forward speed with activated and deactivated suspension system.

Parameter	Speed	Cab suspension system		t	df	p-value
		OFF Mean (SD)	ON Mean (SD)			
Comfort ratings	Low	7.13 (1.93)	7.81 (2.04)	-3.47	15	.003
	High	5.19 (2.37)	7.44 (1.99)	-3.92	15	.001

Considering the data coming from the body map, 5 participants reported body discomfort after the trials with deactivated system (Trials 1 and 3) and 4 after the trials with activated system (Trials 2 and 4). Discomfort was reported mainly arising along the lumbar and neck/shoulders regions (see Figure 2) and it was particularly reported for Trial 3. This was the condition with high forward speed and deactivated suspension. A qualitative analysis of Figure 2 shows that, at low speed, there was a slight difference in reported discomfort with activated and deactivated system (Trials 1 and 2), whereas some more consistent differences can be observed at high speed (Trials 3 and 4). In particular at high-speed with activated system (Trial 4) there was not any discomfort reported for knees and ankles. Similarly, in the same trial, discomfort at neck/shoulders and lumbar area decreases.

Overall, when the cab suspension system was activated, there was a reduced number of participants complaining about body discomfort (from 5 to 4 participants) and a reduced intensity of reported discomfort (from moderate to little), with some exceptions in the lumbar area.

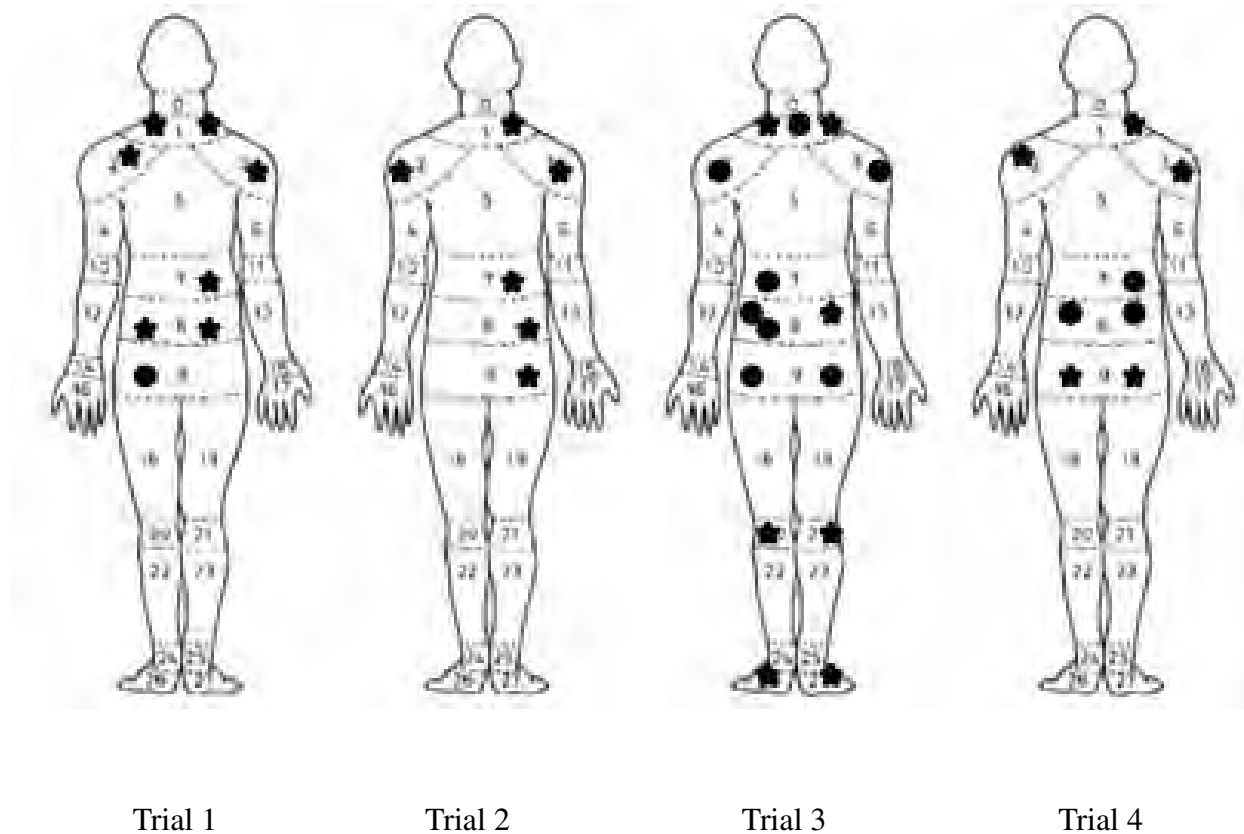


Figure 2. Body maps with levels of discomfort reported by the participants for different body parts during the four trials (star=little discomfort; small circle=moderate discomfort).

Relation between drivers anthropometric parameters, WBV and comfort ratings

The anthropometric characteristics of the participants in the study are reported in Table 3.

Table 3. Anthropometric characteristics of the 16 participants.

	Mean	St.Dev.	Range
Body mass (kg)	88.6	18.5	64-129
Stature (mm)	1751	72	1600-1860
Body Mass Index (kg/m ²)	28.9	5.8	22-42
Hip breadth, sitting	40.6	3.1	35.1-46.5
Sitting height	89.7	4.3	80.4-96.3

The sample was a good representation of the anthropometric variability of the Italian population (ISO 7250-2, 2010; Masali, 2013), with participants from both the 5-10th and the

90-95th percentiles (some participants were even above the 99th percentile with regard to body mass).

Pearson’s *r* correlation coefficients were calculated between anthropometric parameters, WBV measurements along the three axes and comfort ratings for each of the 4 trials. The results are summarized in table 5. The analysis showed that:

- 1) many significant correlations between objective measurements of vibration and the anthropometric parameters, especially on x- and y-axes;
- 2) some significant correlations between subjective assessment of comfort and the anthropometric measurements, especially body mass and BMI;
- 3) no significant correlation between objective measurements of vibration and subjective ratings of comfort.

Table 5. Pearson’s *r* correlation coefficients between anthropometric parameters, WBV measurements along the three axes and comfort ratings for each of the 4 trials.

	Stature	Body mass	Hip breadth	Sitting height	BMI	Trial1 Comfort	Trial2 Comfort	Trial3 Comfort	Trial4 Comfort	Trial1 x	Trial1 y	Trial1 z	Trial2 x	Trial2 y	Trial2 z	Trial3 x	Trial3 y	Trial3 z	Trial4 x	Trial4 y	Trial4 z
Stature	1	.324	.219	.802	-.054	.065	-.047	-.320	-.091	.260	-.363	-.283	.198	-.397	-.444	.251	-.594	-.043	-.350	-.627	.143
Body mass		1	.860 ^{**}	.132	.926 ^{**}	.558 [*]	.563 [*]	.140	.662 ^{**}	-.452	-.201	-.263	-.442	-.305	-.194	-.663 ^{**}	-.690 ^{**}	-.392	-.739 ^{**}	-.653 ^{**}	-.201
Hip breadth			1	-.056	.804 ^{**}	.660 ^{**}	.649 ^{**}	.287	.775 ^{**}	-.560 [*]	.051	-.183	-.609 [*]	-.048	-.136	-.730 ^{**}	-.533 [*]	-.470	-.645 ^{**}	-.456	-.399
Sitting height				1	-.169	-.039	-.136	-.391	-.234	.402	-.586 [*]	-.241	.429	-.602 [*]	-.291	.401	-.383	-.115	-.099	-.420	.130
BMI					1	.551 [*]	.603 [*]	.260	.719 ^{**}	-.575 [*]	-.092	-.182	-.538 [*]	-.184	-.046	-.791 ^{**}	-.498 [*]	-.385	-.650 ^{**}	-.452	-.260
Trial1 Comfort						1	.922 ^{**}	.490	.729 ^{**}	-.428	.107	-.032	-.329	.207	-.020	-.436	-.332	-.275	-.440	-.469	-.558 [*]
Trial2 Comfort							1	.435	.724 ^{**}	-.446	.138	-.122	-.339	.208	-.076	-.434	-.363	-.424	-.331	-.456	-.619 [*]
Trial3 Comfort								1	.459	-.308	.367	-.083	-.258	.349	-.125	-.173	.119	-.001	-.034	.027	-.063
Trial4 Comfort									1	-.454	.346	.257	-.527 [*]	.304	.178	-.634 ^{**}	-.282	-.144	-.503 [*]	-.407	-.231
Trial1 x										1	-.273	.353	.916 ^{**}	-.157	.010	.756 ^{**}	.039	.462	.536 [*]	-.085	.619 [*]
Trial1 y											1	.412	-.376	.927 ^{**}	.303	-.100	.435	.285	.095	.313	-.101
Trial1 z												1	.253	.490	.812 ^{**}	-.002	.329	.453	.294	.176	.309
Trial2 x													1	-.258	.075	.697 ^{**}	.016	.273	.623 ^{**}	-.040	.452
Trial2 y														1	.305	.035	.444	.405	.161	.257	-.098
Trial2 z															1	-.315	.445	.003	.297	.437	-.056
Trial3 x																1	.153	.478	.564 [*]	.030	.479
Trial3 y																	1	.235	.389	.866 ^{**}	-.100
Trial3 z																		1	.054	-.045	.661 ^{**}
Trial4 x																			1	.503 [*]	.230
Trial4 y																				1	-.148
Trial4 z																					1

** . Correlation is significant at the 0.01 level (2-tailed).

* . Correlation is significant at the 0.05 level (2-tailed).

Conclusion

WBV is a well-known risk factor for developing MSDs and it is also an important source of discomfort, which can affect performance and lead to injuries (Kittusamy 2002). For these reasons, WBV has to be constantly taken into account and monitored, by means of different preventive measures and solutions (Tiemessen et al. 2007). This is particularly true for field vehicles, given the work they had to perform and the terrain they have to work on, and the time the users have to spend on the machine (Mayton et al. 2008). The present study showed

that an active cab suspension system mounted on a telehandler was effective in reducing vibration magnitude and improving comfort in a group of professional users.

An ergonomic approach was adopted in the study to highlight consistencies and discrepancies between different sources of data about WBV exposure and comfort, coming from both the vehicle and the users. Anthropometric characteristics of the users have been considered to investigate which range of physical variability was better protected by the suspension system. At low speed the suspension system reduced WBV especially for taller participants, whereas, at high speed, the cab suspension system led to increased comfort for participants with higher body mass and BMI. The cab suspension system did not eliminate discomfort: some neck/shoulder and lumbar complaints seems to remain.

The results of the study are not conclusive and further investigations are needed to improve vibrational comfort in telehandler users. However, the present study may suggest that the operators, given their wide range of physical variability, may need more adjustable or customizable WBV reduction systems: this may be particularly relevant for those users who have characteristics near to the extreme end of the variability (e.g. aging people, women or migrant workers), whose presence is increasing among the workforce population of the developed countries (de Haan & Rogaly 2002; De Schutter 2013; Ilmarinen 2006).

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Development of an app for using a smartphone as vibro-meter for effects on health evaluation

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Abstract

Italian statistics on work safety are pointing out an increasing number of reports about professional diseases. In this frame are considered the whole-body vibrations (WBV) that could affect operators driving agricultural tractors. The common approach to prevent the related pathologies is to measure some situation that could be representative of the task or to refer to existing database with similar tractor and use. This research follows the approach of monitoring in real time and providing for the development during the working day the driver's level of exposure with a vibro-meter developed as an app to be used with a common smartphone.

This application respects the filters and the weights reported on the ISO 2631:1997; the smartphone has an orientation to respect and gives on the three axis the real time data of exposure (the last minute), the daily exposure (referred to 8 eight hours of work) and the time of exposure. The application has been tested on an agricultural tractor in different operative conditions.

The application provides a simple method for an initial assessment of whole body vibration level of exposure. The system can't substitute a certified chain of measurement but could represent a low-cost device for operator's training for practically explaining the question of the dose of vibration and the importance of monitoring the daily, cumulative dose of vibration.

Keywords: Tractor, Safety, Whole Body Vibration, Early Warning.

Introduction

Italian statistics on work safety are pointing out a decreasing trend about injuries and fatalities but an increasing number of reports about professional diseases.

A mean value of 36% more in the last 5 years has been observed but data in agricultural environment have increased of 383% in the same period.

These data show that the interest about the occupational diseases is increasing.

In this frame are considered the whole-body vibrations (WBV) that could affect operators driving agricultural tractors.

European Parliament Directive 2002/44/EEC sets the minimum requirements for protection of workers from risks to their health and safety arising from exposure to mechanical vibrations and, in 2008, Italy adopted a specific national regulation on safety (Decree no. 81/2008).

The vibration risk for tractor's operator depends from the level and the time of the exposure. Monitoring the exposition is particularly difficult for agricultural tractors because of the heterogeneity of environment and working situations that makes not possible to foresee and standardize the operator exposure to vibration. In operations that involve several different tractors or implements the time of exposure is directly function of the operational time of each

operation and is characterized, above all, from the dimensions of the fields and the distance from the farm (Scarlett, 2007; Cutini, 2011; Nguyen, 2011; Sherwin, 2004; Seidel, 1986).

The legislation requires to declare the value of homologation of the seat, but the employer has to evaluate the risk of employees as well. The approach is to measure some situation that could be representative of the job or to refer to existing database with similar tractor and use. This approach is technically correct and recognized from the Authority but doesn't solve the problem of monitoring in real time the driver's level of exposure in specific conditions of work or with a specific tractor (technological level degree of maintenance, etc.).

Another approach that has been introduced concerns the use of vibrometer that could be compared to the use of an exposure-meter, in order to realize a direct measurement of the exposure. The CRA-ING Research Laboratory of Treviglio, Italy, has developed an application for smartphones to measure the exposure to vibration of an operator on the three axis able to predict the development during the working day and provide early warnings.

A first prototype, called INTRAC-vibra, was developed for measuring comfort (Cutini, 2014), according to ISO 2631:1997 part 2, but this doesn't furnish a response about the safety levels of 0.5 and 1 ms^{-2} of the part 1 of the standard, so it was decided to develop a new app.

The new developed application, called INTRAC-safety, respects the filters and the weights of the ISO 2631:1997; the smartphone has an orientation to respect and gives on the three axis the real time data of exposure (the last minute), the daily exposure (referred to 8 eight hours of work) and the time of exposure. The application has been developed in the frame of the INTRAC project, that is addressed to study some fundamental aspect to reduce the risk during the use of agricultural machineries.

Materials and methods

The application was conceived to be used with the most common types of smartphone Android™, for giving a friendly instrument that, anyway, can't substitute the official vibrometers with seat pad.

Vibration assessment reports the measurement of the weighted root-mean-square (RMS) acceleration considered, it respects the filters and the weights of the ISO 2631:1997 and gives the real-time data of exposure and the daily exposure on the three axis.

The weights k_i are multiplying factors defined in the standard and which depends on the point being measured (seat, back or feet) and on the solicited axle (x, y or z). In this case it's referred to the seat and, for experimental studies, carried out on the single axis, it has been assumed:

- $k_x=k_y=1.4$
- $k_z=1$

The filters for weighing the measured acceleration are defined in the cited standard and depend on the point of location and on the solicited axle.

The standard requires a measure of vibrations till 80 Hz, this could be a technical limit for smartphone but studies have pointed out that the solicitation on agricultural tractors and the exposure on drivers have the main content of energy below 12 Hz (Cutini, 2010; Deboli, 2012; Park, 2004; Taylor, 2000).

The system requirements of the smartphone are:

- CPU dual core at 1 Ghz (recommended quad core);
- 512 MB RAM;
- at least 20 MB free in the internal memory of the smartphone;
- operating System Android™ 2.3.x (recommended 4.0. or later).

The software has been tested on an actuator generating vibrations and on an agricultural tractor in different operative conditions.

One plate of a four poster test bench has been used (Bisaglia, 2006), fig. 1.



Figure 1. One actuator of the four poster was used for validating the application INTRAC-safety.

The signals adopted were cyclic and random with the following characteristics:

- C_2Hz_8: cyclic, 2 Hz, 8 mm RMS amplitude;
- C_5Hz_1: cyclic, 2 Hz, 8 mm RMS amplitude;
- C_7Hz_0.5: cyclic, 7 Hz, 0.5 mm RMS amplitude;
- C_10Hz_0.5: cyclic, 10 Hz, 0.5 mm RMS amplitude;
- R_1-5Hz_5: random, from 1 to 5 Hz, 5 mm RMS amplitude;
- R_3-8Hz_2: random, from 3 to 8 Hz, 2 mm RMS amplitude;
- R_1-12Hz_3: random, from 1 to 12 Hz, 3 mm RMS amplitude;

The experimental application was carried out using a standard 4WD agricultural tractor nominal 85 kW power. The tractor was fitted with suspended cab and pneumatic seat.

Data obtained with the smartphone were compared with the certified instruments vibrometer HD2030 and a seat pad triaxial accelerometers PCB Piezotronics 356 B 40.

Previous experimental test carried out with the first app developed for evaluating comfort have pointed out at the actuator an overestimation at low frequencies (<2Hz) and an underestimation at frequencies >7Hz. For this reason it was decided to adopt the possibility of modifying, by a gain, the smartphone response respecting the group of frequencies required from the standard. This could allow also to set the software if differences are present between the different positions of the smartphone (i.e. operator's trousers pocket, seat, cab).

The measurements were carried out on three different surfaces and at different forward speeds (fig.2):

- asphalt test track (AT) at 30 km/h: AT_30;
- field with high skeleton content at 6 km/h: SF_6;
- field with high skeleton content at 6 km/h: SF_9.
- ISO 5008 standard test track at 6 km/h: ISO_6
- ISO 5008 standard test track at 10 km/h: ISO_10
- ISO 5008 standard test track at 12 km/h: ISO_12
- ISO 5008 standard test track at 14 km/h: ISO_14



Figure 2. The grassed field and the high skeleton terrain used for test in working condition

Two different positions of the smartphone were adopted:

- in the pocket of the operator’s trousers: _P;
- on the side beside the operator: _S.

Results and Discussion

The INTRAC – safety application shows the vibration absorbed during all the working time or during the last minute.

It’s possible to install the application as a normal app by downloading and executing the Android™ package with the application “Installer package”.

INTRAC – safety starts touching the icon in the “Applications” section.

The smartphone has to be oriented with the screen upwards.

Touching the symbol ► in the upper right corner, INTRAC – safety will start to register the vibrations of the smartphone (fig.3).

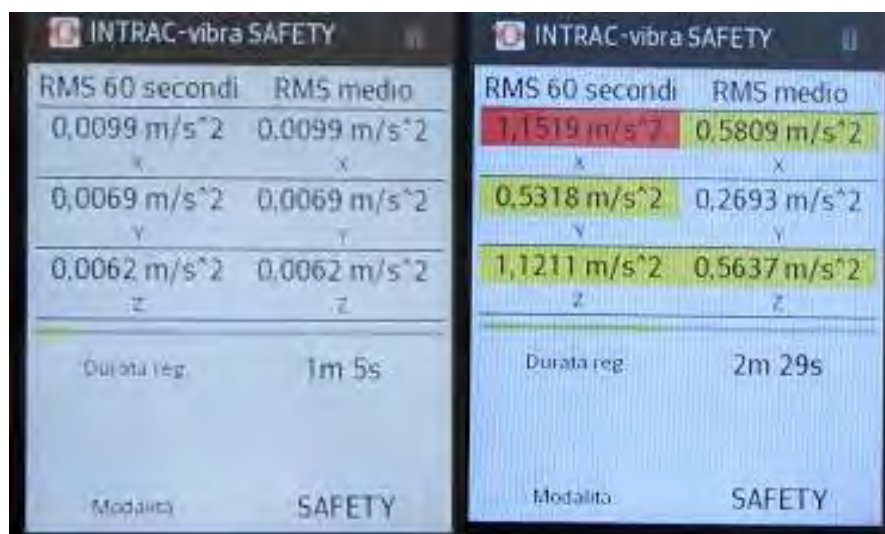


Figure 3. Example of the developed application during working as appeared on the smartphone screen (yellow=uncomfortable; red=dangerous)

After one minute it will start to display the indications. Different levels of alert provide indications to the driver. The yellow fill colour of the value indicates discomfort, the red a value that could be dangerous if considered for 8 hours of exposition.

These limits are, respectively, of 0.5 ms^{-2} and 1 ms^{-2} .

The fields indicate:

- the equivalent level of exposure, each minute (Aeq)
- total RMS of the accelerations measured from the starting of the measurement
- effective exposition time.

The results of the validation of the application at the actuator is reported in table 1.

As expected, it indicates that there's an overestimation of about 20% at low frequencies, less than 5 Hz. This could happen for the different kind of sensibility of the sensors adopted. The value is correct, with an error of about 2%, if the signal is considered between 0 and 10Hz. An underestimation was found with increasing frequencies, in particular over 10Hz (about 30% less).

Table 1. Acceleration value obtained during validation with a setting following the standard

Setting	Vibrometer ms^{-2}	INTRAC-safety ms^{-2}	Mean error %
C_2Hz_8	0.43	0.71	39.4
C_5Hz_1	0.7	0.7	0
C_7Hz_0.5	0.68	0.6	-13.3
C_10Hz_0.5	1.33	1.03	-29.1
R_1-5Hz_5	0.44	0.54	18.5
R_3-8Hz_2	1.5	1.53	2.0
R_1-12Hz_3	0.87	0.78	-11.5

These result confirmed the choice of adopting the possibility of a calibration modifying the gain of the different group of frequencies till 20 Hz. Thanks to this possibility has been optimized the response at the actuator. The smartphone presents difference between 6 and 13% during the random test. The results are reported in table 2.

Table 2. Acceleration value obtained during validation after gain setting

Setting	Vibrometer ms^{-2}	INTRAC-safety ms^{-2}	Mean error %
C_2Hz_8	0.43	0.42	-2.4
C_5Hz_1	0.7	0.67	-4.5
C_7Hz_0.5	0.68	0.66	-3.05
C_10Hz_0.5	1.33	1.27	-4.75
R_1-5Hz_5	0.44	0.51	13.75
R_3-8Hz_2	1.5	1.6	6.3
R_1-12Hz_3	0.87	0.8	-8.8

As already described in the introduction, the standard ISO 2631 requires the measurement of frequencies till 80 Hz. Anyway several studies have demonstrated that the most interesting frequencies, as content of energy, for whole body vibration of operators of

agricultural tractors are below 12 Hz. During the test on tractor, the smartphone can't be posed in the same position of the seat pad, so it's necessary to verify if the results could present values of error similar to those at the actuator. The first tests were carried out with the vibrometer as close as possible to the seat pad. For this reason was chosen as location the seat, beside the operator. Also in this case the gain values were adjusted for calibrating the smartphone with the vibrometer. As the possibility of adjusting the gain is common for the three channels, it was chosen to calibrate the z axis. Results present a mean error of 10%. The worst value of error (40%) was obtained during transport on asphalt but with an absolute difference of 0.24 ms^{-2} . The x and the y axis present higher values than the vibrometer and higher values of error than the z axis. The results are reported in table 3.

Table 3. Acceleration value obtained on a working tractor with the smartphone at the seat

Setting	Vibrometer ms^{-2}			INTRAC-safety ms^{-2}			Mean error %		
	x	y	z	x	y	z	x	y	z
ISO_6_S	0.66	0.88	1.72	1.31	0.86	1.42	97.5	2.2	17.6
ISO_10_S	0.79	0.9	2.01	1.40	1.2	1.78	77.2	33.7	11.3
ISO_12_S	0.77	0.88	1.55	1.31	0.90	1.37	71.3	1.8	11.4
ISO_14_S	0.99	0.87	2.53	1.59	1.12	2.22	60.2	28.5	12.2
SF_6_S	0.42	0.86	0.78	0.77	0.61	0.71	84.2	28.7	8.6
SF_9_S	0.80	0.78	1.89	1.54	1.07	1.75	92.2	37.0	7.2
AT_30_S	0.27	0.33	0.61	0.7	1.37	0.85	155.4	318.1	39.9

As one of the aim of the project is the usability of the system, the approach is to define a comfortable location for the smartphone guaranteeing data repeatability. For this reason has been chosen to put the smartphone in the pocket of the operator's trousers.

The calibration setting defined for the position on the seat has been maintained.

The position resulted, as expected, influencing the mean error, as the seat pad is always positioned on the seat. The z axis presents a mean error of 30% but is interesting that remain constant in all the test apart the SF_9_S. There's a worsening of the y axis response while the x axis presents an error lower than on the seat.

The results with the smartphone in the pocket are reported in table 4.

Table 4: Acceleration value obtained on a working tractor with the smartphone in the pocket

Setting	Vibrometer ms^{-2}			INTRAC-safety ms^{-2}			Mean error %		
	x	y	z	x	y	z	x	y	z
ISO_6_S	0.56	0.86	1.42	0.78	1.43	1.77	38.9	65.8	24.7
ISO_10_S	0.81	0.96	1.8	1.23	1.93	2.3	51.3	100.8	28.0
ISO_12_S	0.78	0.86	1.69	1.13	1.88	2.29	44.7	118.9	36.2
ISO_14_S	0.97	0.86	2.25	1.6	2.25	3.12	64.4	162.7	38.5
SF_6_S	0.31	0.68	0.58	0.42	1.05	0.79	34.9	53.9	35.9
SF_9_S	0.83	0.92	1.49	0.97	1.97	2.63	17.5	114.9	77.0
AT_30_S	0.28	0.3	0.61	0.38	0.64	0.78	37.9	113.9	27.5

The values of the correlation R show a linear relationship between the vibrometer and the smartphone in all the conditions tested for the x and the z axis. This allows to retain that introducing a coefficient could be sufficient for correlating the smartphone position with a correct result. Instead, an in depth analysis has to be carried out for analyzing the response of the y axis that present lower values of linear relationship. In this case the result is retained to be attributed to the low frequencies (<1.5 Hz) characterizing the lateral solicitation that could require a focused setting for y channel. These results are reported in table 5.

Table 5. Correlation analysis (r) between the vibrometer and the smartphone

Position	Correlation	Vibrometer		
		x	y	z
Seat	r (Pearson)	0.97	-0.61	0.98
Pocket		0.96	0.87	0.96

Conclusions

The CRA-ING Research Laboratory of Treviglio, Italy, has developed an application for smartphones to measure and analyze the whole body vibrations regarding the operator's safety. The application has been developed following the requirements of the ISO 2631:1997.

The position of the smartphone resulted influencing results but a correlation was found regarding x and z axis. The setting of the y axis requires an in depth analysis.

The system needs an improvement and verifications with different but could provide a very simple method for an initial assessment of whole body vibration level of exposure.

It could represent a low-cost device for operator's training or for practically explaining the importance of the monitoring of the daily, cumulative dose of vibration.

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Noise, vibration and dust emissions of a forestry chipper

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Abstract

Wood biomass is an important energy source, which is attracting much interest from research and agro-industry. Before energy conversion, wood biomass is generally processed into particles of variable size and shape. This treatment is called chipping and it is performed by chippers. Chipping operations generate much noise, vibration and inhalable dust, which can cause potential health risks for the operators. We tested a chipper (Farmi CH260) with loader feeding for chipping of wood material until 260 mm of diameter, powered by a four wheel driven tractor. The tests of chipping were conducted on seven years old poplar trees. The noise and vibration levels were measured in accordance with the ISO 1999:2013 and the ISO 2631-1:2014 standards. The amount of inhalable dust, during field operations, was evaluated according to UNI EN 481:1994. In line with the requests of the Italian law no. 81/2008 and the measured values of noise and dust emitted and vibration transmitted, we calculated the personal daily exposition to noise, vibration and inhalable dust levels, in terms of $L_{EX,8h}$, A(8) and $mg\ m^{-3}$, respectively, with the aim to evaluate the most risky parameters of the wood chipping operations.

Keywords: Wood Comminution, Operator Seat, Poplar, Whole-Body Vibrations, Exposure Time, Health Protection.

Introduction

The use of forest and agricultural biomass for energy is an increasingly important topic, particularly in light of the recent debate on climate change. The chipping is a central operation that allows the production of wood chips suitable for energy use. The chippers have been mainly investigated in terms of productivity, cost of the operation, and in recent years, the studies have shifted towards the investigation of more specific variables (Röser *et al.*, 2012; Verani and Sperandio, 2014), but the aspects related to operator safety are still poorly investigated.

Italian Legislative Decree no. 81 of 2008 is the comprehensive act concerning the protection of health and safety in the workplaces. As regards physical agents, the title VIII of the Decree deals particularly with noise and vibration. In the "General part" is stated that health surveillance is carried out on the basis of the risk assessment during daily working time (8 hours).

The Decree states that workers exposed to noise that exceeds 85 dB(A) must undergo to health surveillance. Generally, the health surveillance is carried out once a year, and it can also be extended to workers exposed to 80 dB(A), after their request, and if the occupational doctor confirms the necessity of surveillance. The decree still provides a maximum exposure threshold value equal to 87 dB(A).

As to vibration risks, workers subjected to levels above the action values (0.5 m s^{-2} for the whole body) must undergo health surveillance usually once a year or with different periodicity decided by the competent occupational doctor. Moreover, the decree provides a maximum exposition limit equal to 1 m s^{-2} for the whole body.

As to the risk of exposure to dust, the International Agency for Research on Cancer has classified hardwood dusts as carcinogenic to humans (IARC, 1995), and estimated that at least 2 million people around the world are exposed to the harmful effects of wood dust, especially for respiratory and skin diseases.

The Directive 38/1999 EC, transposed in Italy with the Legislative Decree 81/2008, stated a value for occupational exposure limit (OEL) to wood dust equal to 5.0 mg m^{-3} measured or calculated with relation to a reference period of 8 hours. In 2003, the Scientific Committee of the European Commission for occupational exposure limits (SCOEL) has recommended to apply a lower value of exposure limit, between 1.0 and 1.5 mg m^{-3} , without distinction between wood from deciduous and conifers. In the United States the American Conference of Governmental Industrial Hygienists (ACGIH) and the National Institute for Occupational Safety and Health (NIOSH) set the limit value of exposure to 1 mg m^{-3} (both for softwood and hardwood).

This paper reports the results of a simultaneous test aimed at assessing the risk of noise, vibration and dust caused by a forestry chipper during chipping of wood poplar.

Methods

The forestry chipper and the wood material

The chipper used in the test is a Farmi mod. CH260 with loader feeding for chipping of wood material until 260 mm of diameter. The chipper is composed by a disk rotor of 1050 mm of diameter and weight of 240 kg, with two knives mounted radially. The rotor can work at the speeds of 540 and 1000 min^{-1} . The speed of 1000 min^{-1} was adopted in these tests carried out on seven years old poplar trees. The machine was equipped with an hydraulic loader maneuvered by an operator positioned on a specific seat (Fig. 1).



Figure 1. The tested forestry chipper.

The chipping tests were carried out on 16 poplar plants having the average dimensions reported in Table 1.

Table 1. Average dimensions of the poplar plants ($\pm$ standard error).

Base diameter cm	DBH diameter (1.3 m) m	Height m	Mass kg
14.4 $\pm$ 1.0	11.2 $\pm$ 0.7	10.5 $\pm$ 1.2	36.8 $\pm$ 6.2

During the tests, the operator was sitting on the seat of the hydraulic loader that fed the chipper. The plants were introduced in the loading mouth one by one and the whole operation was timed by detecting the operating times for each separate plant. In Figure 2 is shown the correlation between weight of the plants and the time of chipping.

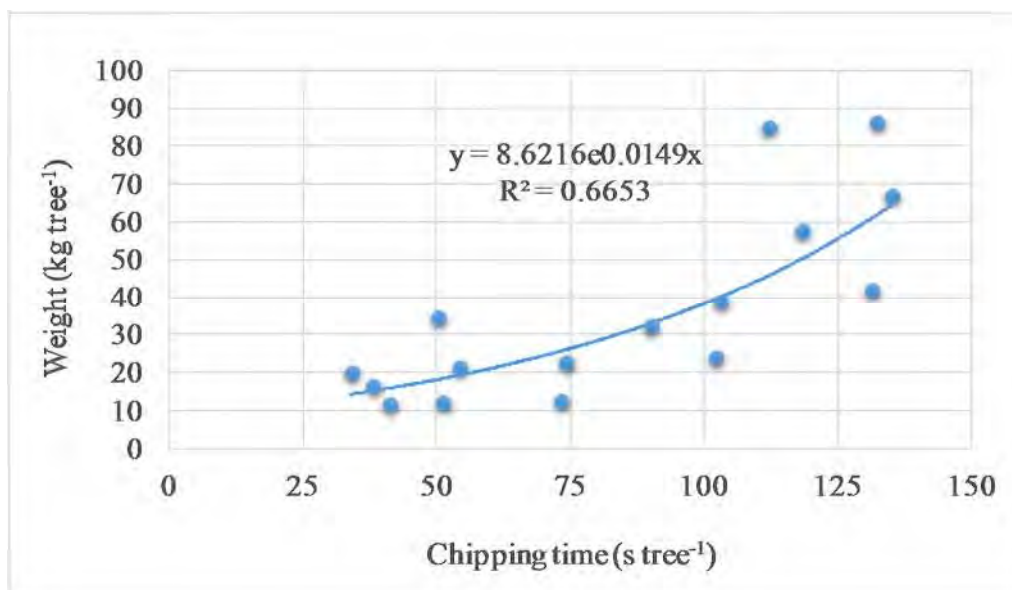


Figure 2. Correlation between chipping time and plant weight.

Measuring instruments

The following instruments were used for the measurements of noise, vibration and dust (Fig. 3):

- signal acquisition and data processing portable system “Soundbook” (SINUS Messtechnik GmbH) with special software “Samurai”;
- microphone Brüel & Kjær, mod. 4189, with wind screen;
- microphone calibrator Brüel & Kjær, mod. 4231;
- triaxial seat pad accelerometer PCB, mod. SEN027;
- calibrator for accelerometers PCB, mod. 394C06;
- personal samplers (air low volume pumps) Zambelli, mod. Ego plus TT.



Figure 3. From left to right: “Soundbook” system for noise; microphone mounted on the operator’s safety helmet; seat pad accelerometer; air personal samplers.

Measurement of sound pressure level

As for the sound pressure, according to the ISO 1999:2013 standard, it was simultaneously measured the continuous equivalent level of "A" weighted sound pressure (L_{Aeq,T_i}) and the maximum C weighted instant sound pressure (p_{peak}). The sound pressure levels were measured for frequency bands in 1/3-octaves in the range 20 Hz - 20 kHz. The measurements were carried out positioning the microphone at 0.1 m from the ear of the operator. Before and after the tests, the deviations from the initial calibration value have been verified by means of the calibrator.

After the measurements, the personal daily exposure levels ($L_{EX,8h}$) were calculated, according to the formula reported by the ISO 1999.

$$L_{EX,8h} = L_{p,A,eqT_e} + 10 \lg\left(\frac{T_e}{T_0}\right) \text{ dB} \quad (1)$$

where:

L_{p,A,eqT_e} is the equivalent level of A weighted continuous sound pressure;

T_e is the actual daily working time;

T_0 is the reference working time equal to 8 h.

After having assessed the noise emission levels, the maximum period of exposure was calculated in compliance with the thresholds set by decree D.Lgs. 81/08.

Measurement of vibration level

The methodology adopted for the measurement of whole body vibration is reported in the international standard ISO 2631-1:2014. The tri-axial seat pad accelerometer was oriented as shown in Fig. 4. The values of the three axial accelerations (a_{wx} , a_{wy} ed a_{wz}) were simultaneously measured in the 0.5 Hz e 80 Hz frequency range.

The level of exposure to vibrations can be assessed by means of the equivalent acceleration weighted in frequency, referred to 8 h of working time [A(8)], calculated with the relation:

$$A(8) = a_v \sqrt{\frac{T_e}{8}} \quad (2)$$

where T_e is the actual daily working time and a_v is the acceleration vector:

$$a_v = \sqrt{(1,4 \cdot a_{wx})^2 + (1,4 \cdot a_{wy})^2 + (1 \cdot a_{wz})^2} \quad (3)$$

According to the standard, in the relation (2), the calculation can be made using, instead of a_v , the higher of the three factors at the second member of the relation (3) if it is much greater than the other two.

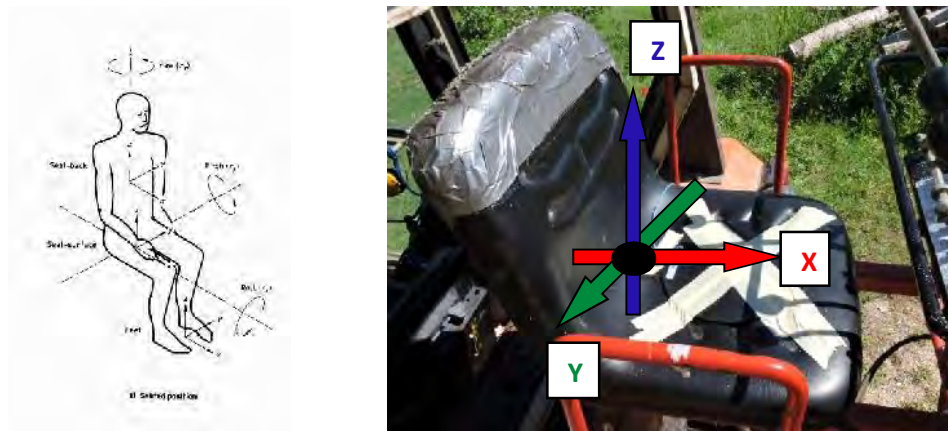


Figure 4. System of coordinates adopted for orienting the seat pad accelerometer, according to the ISO 2631-1:2014.

Sampling of inhalable dust

To measure the concentration of wood dust in the air, two personal air samplers Zambelli (mod. Ego plus TT), were mounted on the frame of the operator's work station. The first sampler was equipped with a cut head "Dorr-Oliver" and it operated at a flowrate of 1.7 L min^{-1} ; the second sampler mounted a conical inlet for measuring the total dust and it operated at a flowrate of 4 L min^{-1} . The sampling was carried out by means of $0.45 \mu\text{m}$ PTFE membrane filter (Millipore, mod. Fluoropore) with a diameter of 37 mm. The mass concentration was determined by gravimetry. All filters were conditioned for 48 h at 50% R.H. before weighing. They were weighted before and after sampling using a $1 \mu\text{g}$ resolution analytical balance (Gibertini Elettronica).

The sampling method and the classification of dust fractions were in compliance with the D.P.C.M. March 28th, 1983 concerning the "maximum acceptable limit of concentration and exposure to air pollutants in external environment", with the standards UNI EN 481:1994 (Atmosphere in the working place: Definition of granular fractions for the measurement of airborne particles), UNI EN 482:2012 (Atmosphere in the workplace. General requirements of the procedures for the measurement of chemical agents) and UNI EN 14907:2005 (Quality of environmental air. Standard gravimetric measurement method for the determination of the $\text{PM}_{2.5}$ mass fraction of the particulate in suspension)

Results

Noise levels

Table 2 shows the values of continuous equivalent level of A-weighted sound pressure ($L_{Aeq,Ti}$) and the maximum value of instant C-weighted sound pressure (p_{peak}).

The values of p_{peak} remain below 87 dB(A), 135 dB(C), as L_{Aeq} are always higher than the exposure limit of 87 dB(A). The values of p_{peak} and L_{Aeq} have been used to calculate the $L_{EX,8h}$ and the maximum utilization time of the forest chipper. In order to not exceed the lower action value [80 dB(A)], the upper action value [85 dB(A)] and the limit value [87 dB(A)], they resulted, respectively, of about 15 min, 30 min and 45 min, very short intervals incompatible with the normal operation, even in presence of workers' rostering. Therefore it is

mandatory the use of PPEs for hearing and their evaluation of their effectiveness prior to purchase.

Table 2. Noise levels at the ear of the operator

Thesis	L_{Aeq} dB(A)	L_{Cpeak} dB(C)
Plant 1-4	97.4	121.9
Plant 5-8	98.6	123.0
Plant 9-12	98.3	122.1
Plant 13-16	97.7	123.5
Average	98.0	122.6

Levels of whole body vibration

The values of the axial accelerations a_{wx} , a_{wy} and a_{wz} are reported in the Table 3 together with the values of the sum vector, a_v . As the axial components multiplied by their relative coefficients have similar values, the calculation of A(8) and of the maximum utilization time were made on the basis of a_v .

Table 3. Levels of whole body vibration measured during the chipping of poplar plants

Tesi di prova	a_{wx} $m\ s^{-2}$	a_{wy} $m\ s^{-2}$	a_{wz} $m\ s^{-2}$	a_v $m\ s^{-2}$
Pianta 1-4	0.312	0.318	0.432	0.763
Pianta 5-8	0.299	0.278	0.399	0.704
Pianta 9-12	0.206	0.268	0.339	0.620
Pianta 13-16	0.191	0.248	0.298	0.532
Average	0.252	0.278	0.367	0.655

The results show that the levels of whole body vibrations transmitted during the chipping are always lower than the limit value ($1.0\ m\ s^{-2}$) defined in the D.Lgs 81/08. The A(8) and the maximum utilization time of the chipper always resulted higher than $8\ h\ day^{-1}$ with reference to the limit value. As to the action value ($0.5\ m\ s^{-2}$), always exceeded it. Considering the average of a_v ($0.655\ m\ s^{-2}$), the time would reduce to about 5 h, thus requiring interventions for the reduction of worker exposure.

Amounts of inhalable dust emitted

Table 4 reports the amounts of breathable dust and total dust emitted during the chipping of the poplar wood sample.

Table 4. Results of the dust assessment.

Dust	Cut head	Sampler flow rate	Sampled air volume	Dust on filter	Concentration	Total dust in 8 h ^(*)
		$L\ min^{-1}$	L	mg	$mg\ m^{-3}$	mg
Respirable	Dorr-Oliver	1.7	53.6	0.07	1.40	13.4
Total	Conical inlet	4.0	125.7	0.38	3.05	53.8

^(*) considering a respiratory rate of $1.2\ m^3$

The concentrations of both respirable and total dust, respectively equal to 1.40 e $3.05\ mg\ m^{-3}$, resulted lower than the exposure limit ($5.0\ mg\ m^{-3}$) ensuring the respect of the

conditions of safety and health according the Legislative Decree 81/08. However, they are higher than the limits proposed by several control organizations (SCOEL, ACGIH, NIOSH).



Figure 5. The workplace and operator during chipping operations.

Conclusions

The test results show that the complexity and variety of forestry work conditions make difficult the assessment of risks for the operator deriving from the exposure to different physical and carcinogen agents. During the chipping of poplar wood, the exposure limits for the dust and, partially, for the vibration were not exceeded, allowing the employment of the same operator, without limitation, for the entire working day.

On the other hand, a drastic limitation of the chipper utilization time is determined by high level of noise emitted by the machine, that represents the limit factor. Basing on these results, the employer is obliged to supply suitable personal protective equipment (PPE) for the hearing, the effectiveness of which must be assured in advance.

The hydraulic loader of the chipper, being devoid of the cabin, does not provide any protection to the operator against the dust and the other microclimatic and environmental parameters. Consequently the operator is exposed to dust generated by chipping. In general, the level of discomfort is increased during summer, by excessive sweating caused by high temperatures.

So considering the work environment and the main types of PPE on the market it is advisable to address the choice on the headset, that is easy to wear and provides an attenuation level close to the standard requirements. Alternatively, expandable earplugs can be conveniently used mainly during summer. Finally, the employer must provide appropriate training and information to workers on the proper use of PPEs and of the operating machines, activating suitable health surveillance for exposed workers.

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Laboratory vibration measurement from hand-held harvesters for olives

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Abstract

Vibration represents the most important risk connected with the use of portable harvesters for olive and other drupe. This research was developed within an inter-laboratory test (Round Robin Test – RRT) with the purpose of measuring the vibration to the hand-arm system produced by one portable harvester. To standardise the measurement under load conditions, a suitable laboratory test bench was used. This paper reports the results obtained by the Section of Mechanic and Mechanisation of the Di3A.

The results showed an average acceleration of 2.6 m s^{-2} in idling running and of 13.6 m s^{-2} under load conditions. The highest component was always along x direction (12.8 m s^{-2} under load), the lowest in y direction (1.8 m s^{-2} under load). The test bench proved to be a useful tool to standardise the test conditions, but further studies are necessary to compare acceleration values measured with the test bench and during harvesting.

Keywords: Safety, Olive Harvesting, Vibration Exposure, Hand-Arm System

Introduction

There is a large use of portable harvesters in olive growing aimed at reducing the harvesting costs. The several types available on the market are generally deficient in terms of safety and ergonomics; weight, lack of comfort, high levels of noise and vibration are the most studied aspects (Blandini *et al.*, 1997; Deboli *et al.*, 2008; Pascuzzi *et al.*, 2008). Vibration is probably the most important risk connected with their use, often underestimated by workers, mainly interested in productivity and then exposed to the appearance of the Raynaud syndrome.

Acceleration values reported in literature present great variability (Monarca *et al.*, 2007; Pascuzzi *et al.*, 2009; Cerruto *et al.*, 2010; Çakmak *et al.*, 2011; Cerruto *et al.*, 2012; Aiello *et al.*, 2012; Calvo *et al.*, 2014; Deboli *et al.*, 2014), so the assessment of the effective risk requires the direct measurement under real working conditions.

This research was developed within an inter-laboratory test (Round Robin Test – RRT), coordinated by Roberto Deboli from the Institute for Agricultural and Earth-moving Machines of Italian National Research Council (CNR), Torino. The RRT had the purpose of measuring the vibration to the hand-arm system produced by one portable harvester. To standardise the measurement under load conditions, the CNR designed and made available to several laboratories a suitable test bench, but each laboratory carried out the measurement using their personnel and equipment. This paper only reports the results obtained by the Section of Mechanic and Mechanisation of the Department of Agricoltura, Alimentazione e Ambiente (Di3A).

The laboratory test bench for vibration measurement

The laboratory test bench consists of a square frame $50 \text{ cm} \times 50 \text{ cm}$ with a mesh of 5 cm (vertical) $\times$ 4 cm (horizontal) of synthetic threads (Figure 1). The horizontal threads have to be subjected to tension manually and then locked by means of clamps, while the vertical ones

are pulled by 1 kg masses. This system ensure an almost constant resistance to the rods of the harvesting head, simulating the canopy action.

The frame is applied to a wood structure, made stably by means of suitable weights on its base. The working height is from 140 cm to 190 cm above the ground, so allowing the test of portable harvesters with an angle of about 45°, as usually it happens during the harvesting of olives from trees.

The portable harvester

The portable harvester used for the experimental tests is driven by an electric motor powered by an external 12 V DC battery. Its harvesting head carries the motor and 8 carbon fibres rods, 350 mm long and with diameter of 5 mm. The running frequency, according to the manufacturer specifications, is about 1400 beats per min under load conditions; an electronic card and a software control the rotation speed of the motor, reducing its value at about 400 rpm in idling condition, so to reduce energy requirements and noise and vibration level. The aluminium-made bar is telescopic, with lengths of 1.55–2.60 m and diameters of 25–28 mm.

The experimental activity

Measurements were carried out both at idling and at full load conditions. The machine was only tested with the minimum bar length (1.55 m). Idling tests were carried out with the bar angled of about 45° and each measurement lasted 30 s. Full load measurements were carried out by using the test bench. To this end, the rods of the harvesting head were inserted into the frame at a depth of about 8 cm. After 5–10 s, the rods were extracted and then re-inserted in a different position of the frame, so simulating the harvesting action in an effective olive tree. The measurement time under load conditions lasted 2 min. Measurements were carried out with the machine driven by four operators and replicated five times for each operator.



Figure 1. View of the test bench designed at the CNR for vibration measurement.



Figure 2. Accelerometer positioning on the bar and reference axes (1: x-axis; 2: y-axis; 3: z-axis).

Acceleration was measured, at different times, next to the hand positions on the bar, at a distance of 85 cm (M1: rear position, near the hand-grip; M2: front position, on the bar) (Figure 2). Weighted rms (root mean square) acceleration values were computed for each reference axis by applying the 1/3 octave analysis in the frequency range 6.3–1250 Hz and then the global weighted acceleration a_{hw} was calculated. Global values were statistically

analysed to detect significant differences related to measuring point and working condition.

Results and discussion

The statistical analysis (Kruskal-Wallis test) of a_{hw} values showed that the only significant difference (p -level = 0.05) was that between working conditions (Figure 3): on average, the global weighted acceleration was 2.6 m s^{-2} in idling conditions, 13.6 m s^{-2} when using the test bench. Further researches will be developed to compare the results between test bench and harvesting conditions: if the difference will be not significant, the test bench may be an effective tool to standardise the test conditions for portable harvesters. The difference between rear (M1) and front (M2) position was not statistical significant: 8.5 vs. 7.8 m s^{-2} . Finally, the differences between operators were not significant too: acceleration values ranged from 7.4 up to 9.0 m s^{-2} .

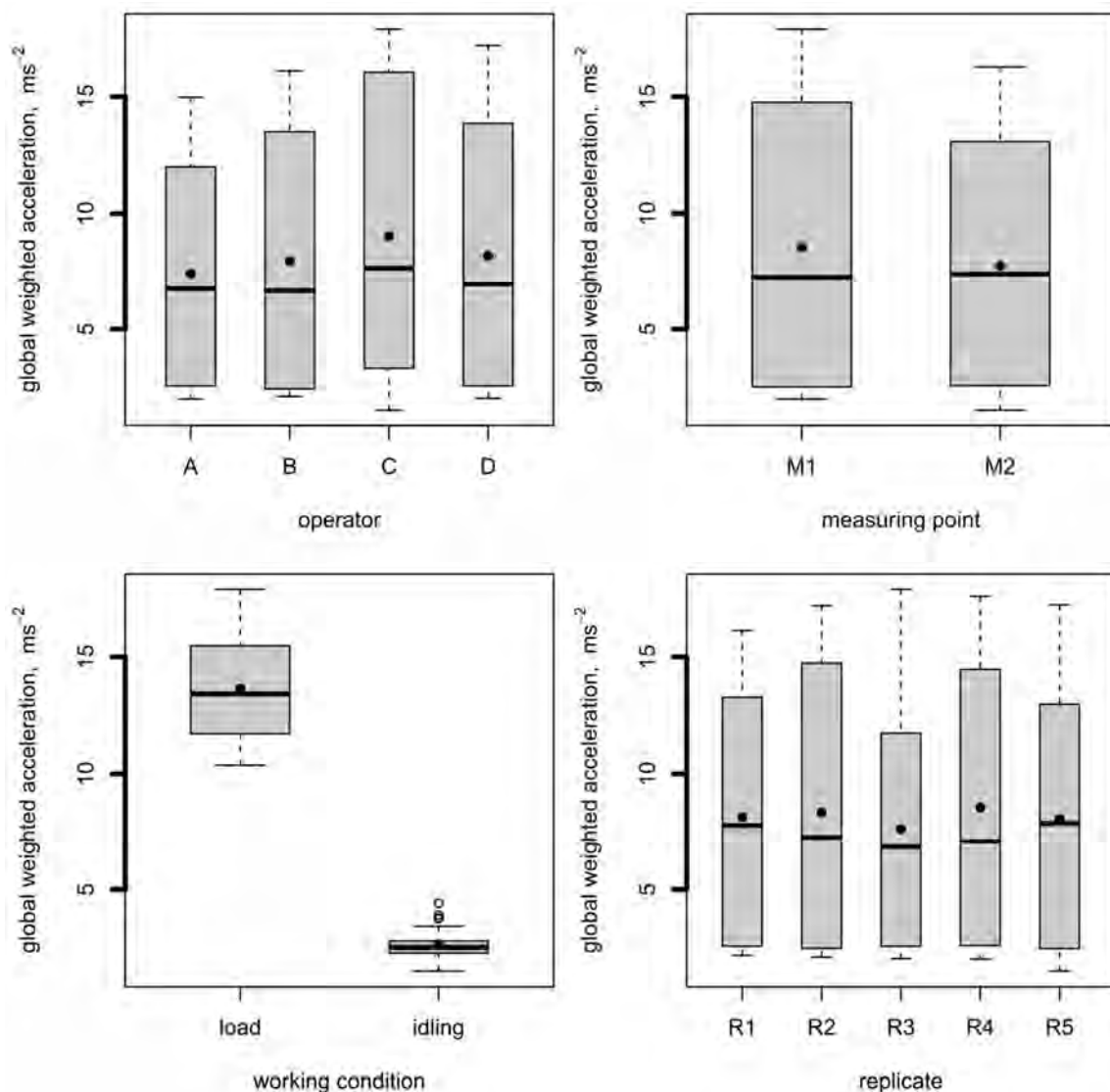


Figure 3. Box-plot of global acceleration values at varying operator, measuring point, working condition and replicate. Points represent mean values.

Weighted acceleration components along the reference axes are reported in Figure 4 at varying the working conditions. In both test conditions, the highest component was that along the x -axis, the lowest that along the bar axis (y -direction). During idling running, the average x -component was 2.1 m s^{-2} , the y -component 0.5 m s^{-2} , the z -component 1.2 m s^{-2} . The corresponding values under load conditions were 12.8 m s^{-2} , 1.8 m s^{-2} and 4.3 m s^{-2} . So, the interactions between rods and threads of the test bench determined an increase in all the acceleration components from 2.3 (y axis) to 5.1 times (x axis).

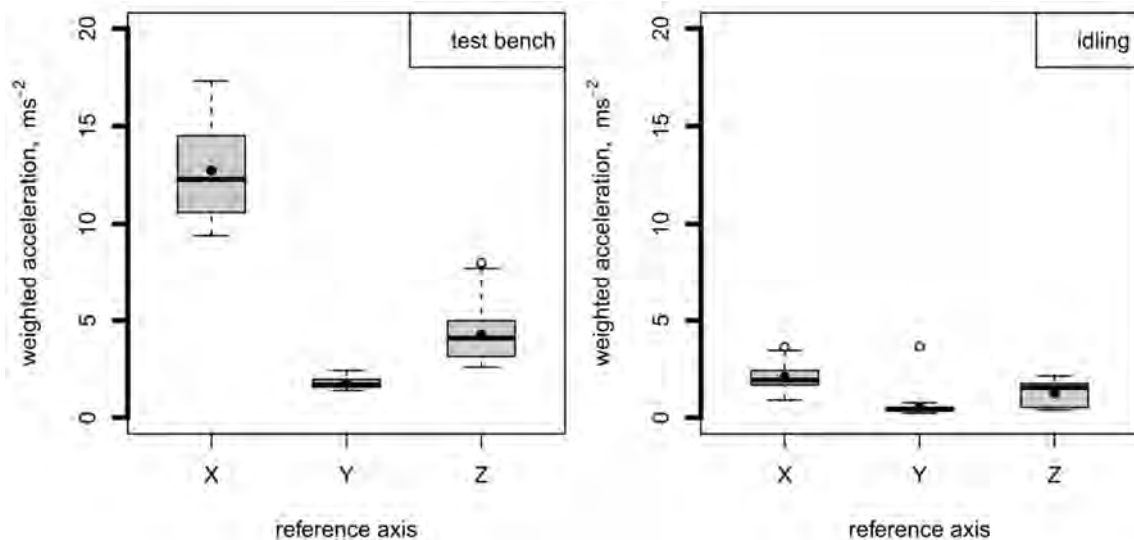


Figure 4. Box-plot of acceleration components values at varying working condition. Points represent mean values.

Conclusions

Portable harvesters for olive harvesting are generally characterised by high levels of vibration and then their use may increase the risk for the safety of the operators. The results of this research confirm this consideration and a lot of studies are still necessary to improve the ergonomic aspects of these machines, mainly regarding the kinematic of the harvesting head.

The average weighted rms acceleration value under load conditions was near 14 m s^{-2} : assuming a daily exposure time equal to 4.5 h (Calvo *et al.*, 2014), the corresponding daily vibration exposure value was 10.5 m s^{-2} , much higher than the action (2.5 m s^{-2}) and limit (5.0 m s^{-2}) threshold values established by the Italian regulation 81/08.

The test bench could be a useful tool to standardise the test conditions. However, further studies are necessary to compare acceleration values measured with the test bench and under harvesting conditions.

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Dust emissions with a new hazelnut mechanical harvesting prototype

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Abstract

The mechanical harvesting of hazelnuts (*Corylus avellana* L.) can show a potential health risk because machinery raise soil particles and dust that can be inhaled by the operators. The paper points out the possibility of reducing the quantity of respirable dust emitted into the atmosphere during the harvesting operations by the use of a prototype pick-up harvesting device, mounted on a self-propelled vacuum machine. The tests were carried out in September 2014, to determine the amount of dust emitted into the atmosphere during the hazelnut harvesting. The tests compared the performance of the machine with the novel device mounted and the same model of the vacuum harvesting machine equipped with the conventional harvesting system (consisting of two counter-rotating brushes with rubber blades). A portable particle laser spectrometer and a personal air sampler with a membrane filter were employed to measure the respirable particulate. In average, a lower concentration of dust was recorded near the operator who drives the harvesting machine, with some differences depending on the employed system (spectrometer or air sampler) to assess the dust concentration. The reduction of dust emission is likely due to the configurations of the novel device, which can contain the dust emitted during the harvesting. Further research will be conducted including the determination of the level of free crystalline silica (SLC), another risk factor for the health of operators.

Keywords: Health, Comfort, Particulate Matter, *Corylus avellana* L., Harvesting.

Introduction

The dust emitted from vacuum machines (sometimes containing high levels of pesticides and herbicides) may cause a high environmental pollution during the harvest period of hazel nuts (*Corylus avellana* L.) and constitute a serious risk to the worker's health (Biondi *et al.*, 1992). Engineering solutions have already proposed to reduce the dust drift (Biocca *et al.*, 2012; Cecchini *et al.*, 2012; Fedrizzi *et al.*, 2012).

This paper would point out the possibility of using a self-propelled hazelnuts mechanical harvester, which performs its harvesting action through mechanical action with pneumatic suction, limiting the emission of dust in the ambient air. An useful solution may be represented by the employment of the pickup type machines for gathering the fruits from the orchard floor (Ghiotti, 1989). In fact pickup models use a rotating brush to lift the fruits that are then carried forward in the machine passing through succeeding mechanical cleaning and sieving devices. When the orchard floor is covered with grass dust emission is reduced (Fanigliulo and Tomasone, 2009), but this practice remains less common. Being aware of this issue the FACMA, a company based in Vitorchiano (Viterbo - Italy), designed and developed a new prototype pick-up harvesting machine, mounted on a self-propelled vacuum machine. The aim of this work was to evaluate the new technical solutions applied to the machine and

to appraise the performance with specific harvesting tests, with particular emphasis to the reduction of dust production.

Methods

The prototype of pickup harvester, model “RM210” (Figure 1), is a self-propelled machine developed for hazelnuts harvesting from the orchard floor. The prototype is powered by Diesel engine, rated 64 kW (86 CV) at 2600 RPM, and complying with the EC/EPA Step 3A emissions standards. The machine has three drive wheels, of which the steering one is placed in the front end of the frame. Power transmission from the engine to the wheels is hydrostatic with differential valve lock on the hydraulic motors coupled to the wheels.



Figure 1. The harvesting vacuum/pick up machine mod. Facma 300 S - RM 210 during the harvesting test.

The hydraulically operated sweeps, placed in the harvester head, gather the product, previously fallen to the ground, into a windrow. The pivoting movement allows the sweeps to follow the soil's profile, reducing the number of fruits left on the ground when not intercepted by the sweeps. The harvesting unit has a total theoretical working width of 2.8 m. A horizontally rotating cylindrical brush, provided with rubber paddles, is placed in the header perpendicularly to the forward direction. The brush, rotating in a direction opposite to the wheels, lifts the nuts from the ground.

The product is so tossed behind and suctioned from the vacuum chamber. The fruits fall onto a cylindrical sieve apparatus for a further sorting of the product, separating all the debris that have a diameter different from that of the hazelnuts. Finally an air stream carries the fruits to sacks held on a tractor-mounted platform or otherwise the nuts are transferred for the final storage, through a flexible tube connection, to a towed trailer with a pantograph lift system for unloading the material. The horizontal cylindrical brush is inserted in an enclosing cylindrical frame, which in the front half holds a metal grid wall. The fine soil passes through the grid from the beginning, while the fruits are lifted from the ground.

Dust falls into a collect chute, holding an auger that pushes the material to the centre of the header. From an opening the dirt is discharged on the ground to one side along the row. The rotation of the auger is powered by a hydraulic motor. The grid helps to remove the soil picked along with the fruits, before it is broken up into smaller particles, so producing lighter dust particles that are more difficult to separate.

The tests were carried out near Sipicciano (Viterbo) Central Italy, (about 42° 31'13" N and 12° 13'17" E) in orchard planted with Italian variety of “*Tonda di Giffoni*” (Figure 2). The test was performed with low or absent wind (mean 0.3; minimum 0.0; maximum 0.5 m sec⁻¹) with average temperature of 25.2° C and relative humidity of 61.2 %.

The orchard floor was covered by a natural grass. The plants had a multi-stemmed training system. Crop management adopted the controlled fine mown turf technique, carried out by making 3-4 passes for each year with a flail mower (starting from spring up to September, just before harvesting time) depending on the seasonal rainfall trend.

The machine settings for an optimal working configurations were made by FACMA's technical personnel. These regarded mainly: working forward speed and horizontal sweep speed.

Particulate matter (PM) released during the harvesting was sampled on the operator (personal sampling). Personal sampling was carried out by means of an air pump (Zambelli) equipped with PTFE filter membranes, without cutting head, worn by the driver and operating at a flowrate of 4 L min⁻¹, and by means of a portable particle laser spectrometer “Dust track” (TSI Inc.) real-time dust monitor, which can simultaneously measure mass and size fraction (Figure 3), placed in the driving seat.

The tests included two repetitions for each thesis; each plot was composed of three rows of 35 plants (total 410 plants). The test compared the innovative machine with the same machine without the harvesting device mounted (traditional configuration) (Figure 4). During the harvesting tests, the main information regarding the functional aspects of the harvester were also acquired.



Figure 2. The test plot.

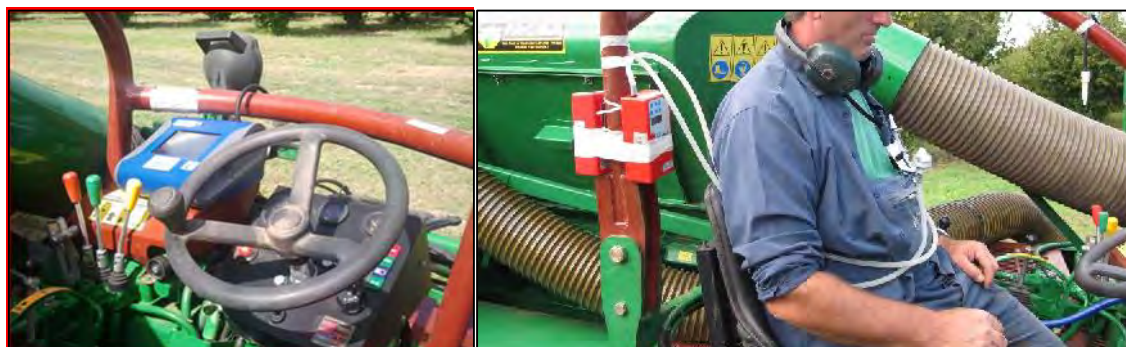


Figure 3. Placement of air samplers on the driving seat (left: “DustTrack”; right: air personal sampler).

Results

The results of the dust sampling, reported in Table 1, showed a slight, but not significant, increased lifting dust from the prototype. Differently, the result of measurements carried out with the laser photometer showed that the prototype pick-up type harvesting machine showed (on average) a reduction in dust concentration of 18.3% with respect to the conventional machine.

Gravimetric analyzes were carried out with samplers without cutting head, while the photometer laser was equipped with a Dorr-Oliver head, for the sampling of the respirable fraction (fractions around the aerodynamic diameter of 4 μ m). If we consider these different sampling methods, the prototype tested in the field showed lower amounts of fine particles raised (monitored near the driving position).

In fact, the prototype is equipped with a harvesting pick up that “traps” a certain amount of dust, before the aspiration toward the loading hopper. In this way it produces a lower overall quantity of the dust because minor amount of dust can reach the rear cyclones dust abatement.

It is likely that the measurements carried out close to the driving position, take account of this fact. Essentially, the sampling of the total dust is localized, and it referred to the front area of the machine, while in the case of fine particles, which remain raised for a long time, the sampling is index a measure more generalized respect to the position of the sampler.

Table 1. Average concentration of airborne particulate (mg m^{-3}) during harvesting with the traditional machine and the prototype and percentage of dust reduction.

Machine	Air sampler	Sampling method		
		min	“Dust track” max	average
Prototype	8.0	0.001	1.71	0.134
Conventional	7.9	0.004	2.57	0.164
Average reductions	+1.3%			-18.3%

Conclusions

In conclusion, the prototype of the self-propelled hazelnut is an innovative and efficient, suitable for the harvesting from the ground of fruit in shell. In the test conditions, the comparison with the conventional machine with rotating brush showed that the prototype can reduce the overall amount of dust raised from the ground.



Figure 4. The harvesting vacuum machine mod. Facma 300 S, equipped with 2 rotating sweeps

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A filtering-recycling device to reduce dust drift from pneumatic drills

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Abstract

The utilization of dressed seed is a widespread practice to control pests and diseases with reduced doses of pesticides. In recent years, some insecticides employed in seed dressing (namely neonicotinoids and fipronil), have been claimed to contribute to honey bees (*Apis mellifera* L.) spring mortality and decline. Pneumatic precision drills used in maize (*Zea mays* L.) sowing can release amounts of dust coming from the abrasion of dressed seed. To reduce dust spread, we developed an effective prototype device for pneumatic drills, which uses partial recirculation and filtration of the air by means of an anti-pollen filter and an electrostatic filter. Tests at fixed point (simulating sowing of maize seed treated with imidacloprid, thiamethoxam, clothianidin and fipronil) were carried out to assess the efficiency of prototype. Measurements were carried out by sampling, with different methods, the air emitted by the drill in different configurations. With the application of the prototype having the double filtration (anti-pollen plus electrostatic filters), gravimetric and chemical analyses of samples showed values of reduction of emissions always greater than 90%, both in terms of the total mass dust and of the a.i. The application of the electrostatic filter to the system resulted particularly efficient in the reduction of the smaller particles (up 4 µm of diameter). The contribution to the reduction of the sole recirculation system was around 70%. This study contributed to the description of abrasion dust in terms of particle size distribution and provided elements which are useful to further development of the prototype.

Keywords: Neonicotinoids, Honey Bee, Seed Coating, Particulate, Aerosol, Pesticides

Introduction

Pneumatic precision drills (Fanigliulo and Pochi, 2011; Foqué *et al.*, 2014) have a seed distribution system based on the vacuum effect created by a centrifugal fan. The sucked air is expelled through the fan opening, dragging with it abrasion dust and seed particles containing dressing (or coating) substances. The drift of dust containing insecticide active ingredients (a.i.) can contribute to the observed mortality or sub-lethal effects on honey bees (*Apis mellifera* L.) and other pollinating insects (Nuyttens *et al.*, 2013; Goulson, 2013). Honey bees can come into contact with these compounds in a number of ways (Greatti *et al.*, 2006; Girolami *et al.*, 2009; Samson-Robert, 2014; Bonmatin *et al.*, 2015), including aerial powdering with particulate matter containing pesticide residues, during their flight (Marzaro

et al., 2011; Pochi *et al.*, 2012). Due to small dimensions of the airborne matter, the drift of abrasion dust containing a.i. can affect large areas, potentially harming the environment and the health of agricultural workers (Biocca *et al.*, 2013; Biocca *et al.*, 2014) and bystanders. Several factors can affect the extent of the dust drift, such environmental conditions, quality of seed coating, physical properties of dust particles and design and settings of drills.

CRA-ING has developed an innovative device applicable to pneumatic drills to achieve an effective reduction of abrasion dust emissions (Pochi *et al.*, 2015). The prototype uses partial recirculation and filtration of the air by means of an anti-pollen filter and an electrostatic filter.

This paper reports the results of tests, carried out at fixed point, aimed at evaluating the prototype efficiency in reducing drift of dust containing four different insecticides.

Methods

Seeds

Commercial maize seed (Pioneer Hy-Bred PR32G44), dressed with Gaucho™, Poncho™, Cruiser™ and Regent™ (respectively a.i: imidacloprid, clothianidin, thiamethoxam and fipronil) and a fungicide (Celest™, a.i.: fludioxonil and metalaxyl) was employed in the tests. The application dose (mg seed⁻¹) was: 1.00 for the imidacloprid, 1.25 for clothianidin, 0.60 for thiamethoxam and 0.50 for fipronil.

Pneumatic seed drills

The sowing machine was a six-row, pneumatic precision drill by Gaspardo (mod. Magica). It was set for a planting a layout of 0.75 x 0.18 m, approximately corresponding to 75,000 seed ha⁻¹. It was originally equipped with a system of four air deflectors, previously tested (Biocca *et al.*, 2011; Pochi *et al.*, 2011). The drill was implemented with two innovative devices (Fig. 1) developed at CRA-ING (called here “APF” and “Electrostatic”). The prototype “APF” works to maintain the abrasion dust, as much as possible, inside the machine by means of a system that recirculate the fan air normal output.

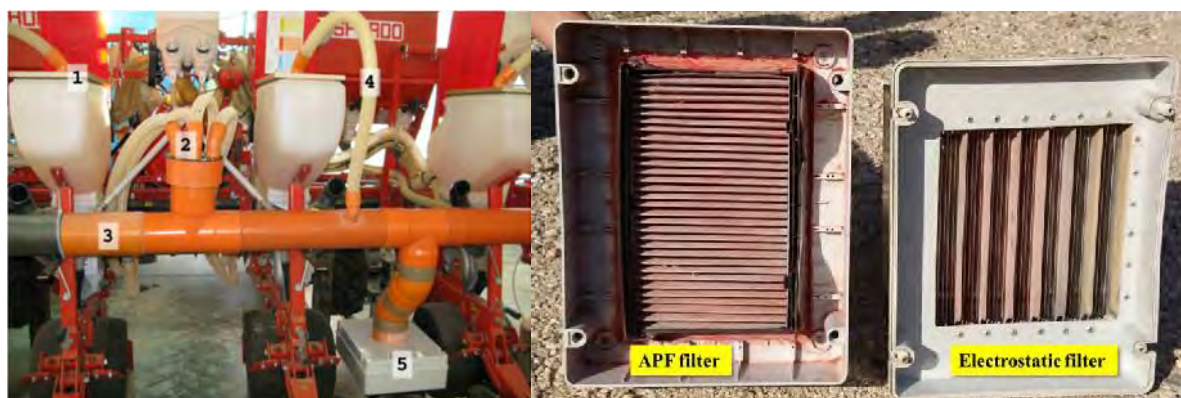


Figure 1. Left: the drill with the device developed at CRA-ING. (1) airtight gasketed lids replacing the normal lids and provided with pipes channelling the air from main collector (3) into the hoppers. (2) collector of pipes coming from the drill's fan; (3) main pipe collector; (4) recycling pipe from hopper to main collector; (5) box with filters, that discharges the filtered air toward the ground. Right: the filters dismounted after use.

The air deflectors was employed to convey the air into a PVC main collector, acting as a compensation chamber of the air pressure. From here, the air flows into the six hoppers, provided with airtight gasketed lids. The air in excess in the system is channelled outwards from the lower side of the main collector, through a box.

The box contains an anti-pollen filter with activated carbon (anti pollen filter)(Bosch), used for air filtration in car cabs (Fig. 1). The prototype “Electrostatic” differs from “APF” only for the presence of an additional electrostatic filter (Expansion Electronics, mod. FE-250) placed before the air exit, to obtain a double filtration (Fig. 1). The electrostatic filter alone has not been tested, so in this work the thesis “Electrostatic” always refers to a double filtration effect. The device is the subject of the international patent application No. PCT/IB2011/053736 (August 25th , 2011).

Test methods

The drills were tested in different configurations using seed dressed with four a.i. (Tab. 1).

Table 1. Sampling scheme (CN= cellulose nitrate filter; PTFE =Teflon filter; OLC = optical laser counter).

Active ingredient	Drill configuration	Sampling
thiamethoxam	Electrostatic	CN, PTFE, OLC
	APF	CN, PTFE, OLC
	Recirculation	CN, PTFE, OLC
clothianidin	Electrostatic	CN, PTFE, OLC
	Recirculation	CN, PTFE, OLC
imidacloprid	Electrostatic	CN, PTFE, OLC
	APF	CN, PTFE, OLC, impactor
	Recirculation	CN, PTFE, OLC, impactor
	Conventional	CN, PTFE, OLC
Fipronil	Electrostatic	CN, PTFE, OLC
	APF	CN, PTFE, OLC
	Recirculation	CN, PTFE, OLC, impactor

The drill configuration named “Conventional” alludes to the drill without any modification; the configuration “Recirculation” is the prototype without the filters (i.e. the drill with the only recirculating circuit mounted); the configurations “APF” and the “Electrostatic” are the complete prototypes (i.e. with filters and recirculating circuit). All the trials were carried out maintaining the drill at fixed point, lifted from the ground, to simulate the sowing of a given amount of seed. The Power Take Off of a 60 kW tractor operated the centrifugal vacuum fan, to generate a -45 mbar pressure. An electric engine, connected to the sowing driving wheel by means of 40/1 gear-reducer, was powered by an inverter (Omron Varispeed V7) to obtain a virtual working velocity of 1.67 m s^{-1} . The distributed seeds were collected in vessels placed under the sowing units and shielded from possible side wind. The time of each single sowing was variable (ranging from 15 to 93 minutes) depending on the seed availability and on the sampling purpose.

Air sampling

In order to test the prototype efficiency, it was carried out a series of samplings of the dust in the drill’s air outlet, with different configurations of the drill. The air samplings were executed in a sampling pipe consisted of a PVC, straight, 2 m long pipe, with diameter of 118 mm, that normalize the air velocity and minimize the particle impacts on the pipe walls. The sampling pipe received the air expelled by the drill by means of deflector pipes connected to the fan air outlet of the drill. An anemometer (TSI, mod. Velocicalc 9535) was inserted into the sampling

pipe to continuously monitor the air speed, allowing airflow calculation. The required isokinetic conditions were identified in preliminary tests.

The air sampling was obtained by means of probes suitably inserted into the sampling pipe. The following determinations were carried out:

- 1: sampling with membrane filters of cellulose nitrate (CN) for gravimetric determination;
 - 2: sampling with 0.45 µm PTFE (Teflon) membrane filters (diameter 47 mm) to determine the amount of contained a.i;
 - 3: sampling with a multi-stage impactor (Micro-Orifice Uniform Deposit Impactor, MSP-USA, mod. 120), to determine the size distribution of the dust particles within ten size classes (µm): > 18 µm; 10-18; 5.6-10; 3.2-5.6; 1.8-3.2; 1.0-1.8; 0.56-1.0; 0.32-0.56; 0.18-0.32; < 0.18; the filters underwent both to gravimetric and chemical analyses. To collect a significant mass of dust, this sampling was limited only to the thesis with a sufficient quantity of seed (Table 1);
 - 4: determination of the instant numeric concentration of particles within 15 size classes (from 0.3 to 20 µm) by a Grimm 1108 optical laser spectrometer (OLC) (sampling period: 3 s).
- The samplings with membrane filters (No. 1 and 2) were carried out by low volume air pumps (Tecora, mod. “Bravo”).

The concentration of mass in the filters was determined by gravimetry. All filters were conditioned for 48 h at 50% R.H. before weighing. They were weighed before and after sampling using a 1 µg analytical balance (Gibertini Elettronica).

Chemical analyses

The determination of active ingredients in the samples was carried out at CRA-PAV by means of HPLC coupled to a MSD (Mass Spectrometry Detector) operating with an ES+ (Electrospray Ionisation Interface, positive mode), as described in Biocca *et al.* (2011).

Results

The results of gravimetric and chemical analyses of membrane filters (PTFE and NC, respectively) are reported in Table 2. The data clearly show the efficacy of the filtering system to retain the abrasion dust. In the case of prototype with the sole APF filter, the reduction of emissions (average of three a.i.) is around 94%, both in terms of a.i and mass reduction; with also the electrostatic filter mounted, the reduction increases.

For the a.i. imidacloprid, the comparison involved all the drill configurations and the percentage of reduction is expressed with regard to the conventional drill (i.e. configuration without neither the filter nor the recirculation). This test allows to assess the contribution of the sole recirculation to the total reduction of mass emission and consequently the synergic effect of the filtration and of the recirculation. It seems that about 75% of the dust mass and the 92% of the a.i are retained by the sole recirculation system.

Depending on the a.i., the data show a difference between the emission reduction both in terms of the content of a.i. and in terms of dust mass. In general, there is a greater reduction of a.i. than of dust mass. In other words, it seems that the filters retain a part of dust that contains a greater concentration of a.i.

Table 3 shows the results of the air sampling with the multi-stage impactor. As mentioned, due to seed availability, only three thesis were tested with this sampling.

The figure 2 shows the pattern of particle size distribution obtained with the impactor, in terms of concentration (µg m⁻³) both of a.i. and mass. For the a.i. imidacloprid, the filtration with APF causes a major reduction of the particles greater than about 4 µm of aerodynamic diameter in comparison with the sole recirculation system. This effect is particularly evident in terms of mass.

Table 2. Concentrations of particulate matter and active ingredients ($\mu\text{g m}^{-3}$) obtained with the air sampling with the filters and percentage reductions caused by the prototype system (t = thiamethoxam; c = clothianidin; i = imidacloprid; f = fipronil).

Test configuration	Tested a.i.	Active ingredient $\mu\text{g m}^{-3}$	Mass $\mu\text{g m}^{-3}$	Reduction in a. i. %	Reduction in mass %
Electrostatic	t, c, i, f	1.4	97.1	99.6	97.4
APF	t, i, f	27.3	179.7	94.7	94.5
Recirculation	t, c, i, f	543.7	2809.5	92.0	74.8
Conventional	i	2704.2	5669.0		

Table 3. Total concentrations of particulate matter and active ingredients ($\mu\text{g m}^{-3}$) obtained with the air sampling with the impactor (sum of 10 stages) and percentage reductions caused by the prototype system (i = imidacloprid; f = fipronil).

Test configuration	A. i. name	A.i. $\mu\text{g m}^{-3}$	Mass $\mu\text{g m}^{-3}$	Reduction in a.i. %	Reduction in mass %
APF	i	4.3	139.6	91.8	50.8
Recirculation		52.2	284.0		
Recirculation	f	99.4	371.2		

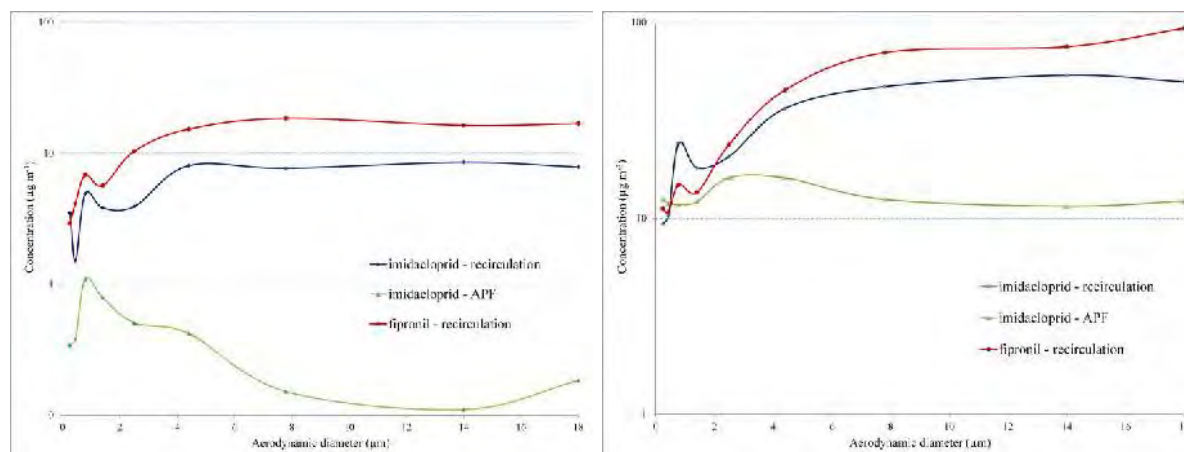


Figure 2. Particle size distribution obtained with the sampling with the multi-stage impactor, in terms of concentrations of a.i. (left) and mass (right).

The sampling with the laser counter allows the determination of the particle size distribution in a different scale of the impactor. Nevertheless, the plot in figure 3 shows once again the strong efficacy of the prototypes in the reduction of emissions. Figure 3 shows the average reduction for all a.i.; it seems that, up to 4 μm of diameter, the electrostatic filter can retain more particles than the APF filter; after this values, the average performance of the two filters is similar, with a slight increase of reduction caused by the sole APF filter for the particles greater than 12 μm .

The figure 4 shows the results obtained with the sampling with the laser counter. The data are expressed in terms of percent number of particles in each size class. Under the diameters of 4 μm , the electrostatic filter retains more particles than the APF filter. This observation is similar from the same data expressed in terms of percentage reduction (fig. 3) where, as mentioned, a threshold of 4 μm has been noted. The figure shows also as the most part of particles have small diameters, generally below 2.5 μm (PM_{2.5}).

Conclusions

In this study we showed the efficacy of a novel system mounted on the drill to reduce the amounts of dust emissions during the sowing. A specific trial procedure (consisting in tests carried out with the drill operating a simulated sowing, at fixed point) allowed different kind of samplings of the air stream emitted by the fan of the drill.

The whole innovative device is based on a double treatment of the airflow produced by the drill: the recirculation and the filtration. Firstly, the airflow deposits a part (about 72%) of the dust particles inside the pneumatic circuit of the drill (recirculation effect) and then, particles are retained by an APF filter (about 94%). The electrostatic filter can act a further filtration, reaching around 99% of emission reduction with respect to the conventional (unmodified) drill. The test system was based on measurements of the dust both in terms of gravimetric values and of analysis of chemical content of a.i. Comparing the results obtained in the different configurations, the percentage of the reduction of dust emission is stronger in case we consider its a.i. content, suggesting that the filters can retain fraction of particles with a greater a.i. concentration.

The use of the prototype can be useful in reducing the emissions of dust containing pesticides and to guarantee a healthier workplace for the operator during the sowing. In the same time, the use of the prototype requires a proper handling of the filters, where the dust, that would have been spread in the environment during the sowing, is concentrated. Besides the low dispersion of dust and a.i. in the environment, perhaps, the main advantage from the use of the prototype is that the problem of dust dispersion is displaced from uncontrollable conditions, like the sown field, to controlled conditions, as the farm center, where all the necessary precautions can be taken to avoid the risk for both environment and operators. The lifetime of a filter can be assessed with specific tests. At the end of its lifetime, the filter must be replaced by a new one. The exhaust filters should be considered as toxic wastes derived from the use of pesticides.

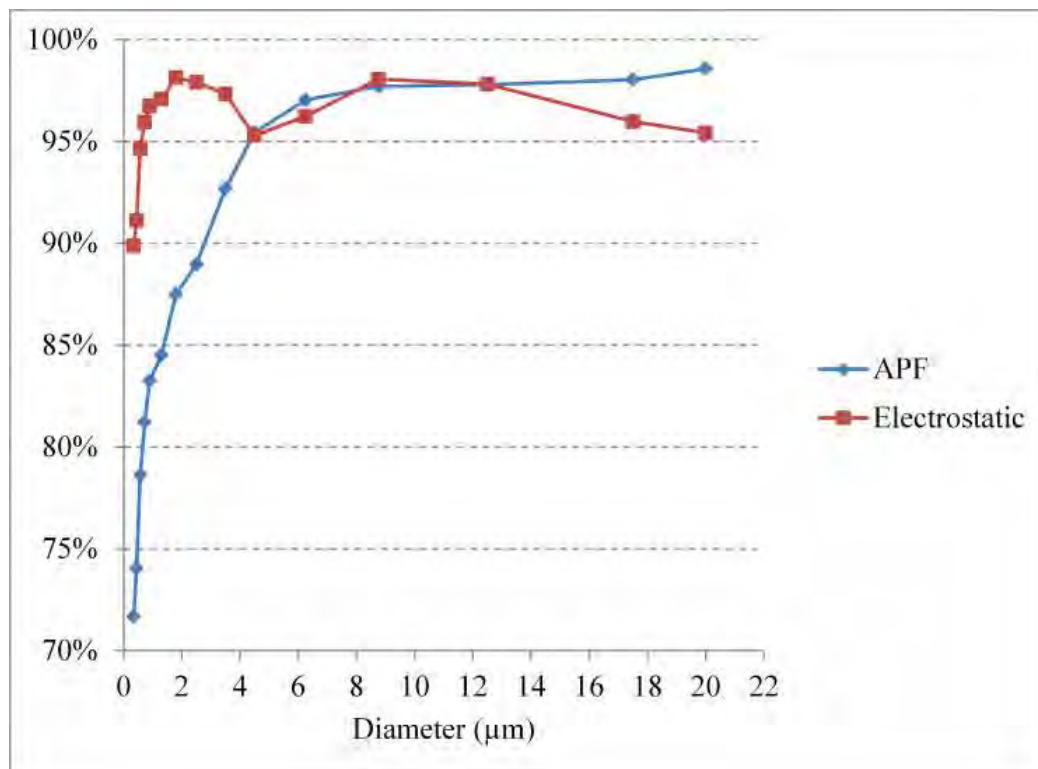


Figure 3. Reduction of particles caused by filters with respect of the recirculation system (average of the four a.i.), in the sampling with the optical laser counter (OLC).

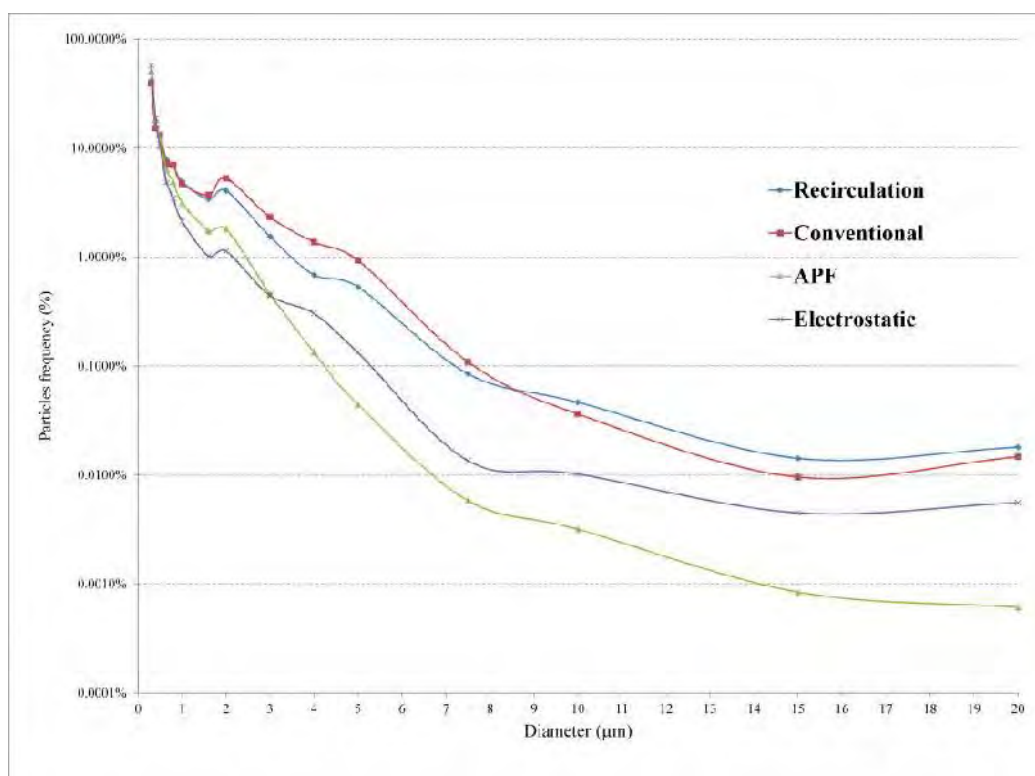


Figure 4. Frequency of particle numbers in the sampling with OLC for the different drill configurations and active ingredients. The vertical axis is in logarithmic scale.

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Risk of exposure to fluoro-edenite fibers of agricultural workers operating in Biancavilla's territory

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Abstract

The municipality of Biancavilla lies on the slope of the Mount Etna, the highest active volcano in Europe, sited in Sicily (Italy), the widest Isle of the Mediterranean sea. A significantly increased standardised rate of mortality from pleural mesothelioma recorded among its inhabitants is comparable to that reported in asbestos-exposed cohorts (Di Paola et al., 1996). This mortality rate has been attributed to exposure to a fibrous amphibole identified by Gianfagna and Oberti (2001) as fluoro-edenite (FE). In the present study, in order to assess the concentration and diffusion of airborne FE fibres in the farmland around the municipal territory, we have used a previously validated sheep model (Rapisarda et al., 2005), as a biological indicator of fibre pollution. In this way it is possible to assess the risk of exposure to FE fibers run by agricultural workers.

Once the risk is ascertained, we are planning to focus on a health surveillance program for this category of workers, so that any pathologies deriving from such unexpected exposure can be prevented.

Introduction

The municipality of Biancavilla lies 515 m above sea level on the SW slope of the Etna volcano in Sicily, Italy. It extends for about 70 km² from Mt Etna to the river Simeto and the town occupies a twentieth of its territory. The economy of the city is mainly based on agricultural, sheep and cattle breeding and meat and dairy products.

A significantly increased standardised rate of mortality from pleural mesothelioma recorded among its inhabitants is comparable to that reported in asbestos-exposed cohorts (Di Paola et al., 1996). This mortality rate has been attributed to exposure to a fibrous amphibole identified by Gianfagna and Oberti (2001) as fluoro-edenite (FE), chemically similar to tremolite except that its OH groups are replaced by fluorine. FE fibres have been found in inert materials, such as sand and rubble, extracted from a stone quarry excavated inside the Mt Calvario, lying on the immediate outskirts SE of the town. This material has been widely used for about 50 years for local building (Comba et al., 2003; Paoletti et al., 2000; Rapisarda et al., 2003).

FE has been recently classified by the IARC as carcinogenic to humans (Grosse et al., 2014).

In a previous study we identified a high risk of pleural plaques in building workers occupationally exposed to FE (Rapisarda et al., 2015).

In the present study, in order to assess the concentration and diffusion of airborne FE fibres in the farmland around the municipal territory, we have used a previously validated sheep model (Rapisarda et al., 2005), as a biological indicator of fibre pollution. In this way it is possible to assess the risk of exposure to FE fibers run by agricultural workers.

Our results seem to demonstrate that a few kilometres from the town there is a certain risk for agricultural workers of inhalation of the dust particles, particularly FE fibres, from the Mt Calvario quarry. Similar results were found by DeNardo and coworkers (2004); they asserted that fiber exposure risk is not confined to the urban area, raising the possibility of hazard to the rural community.

Materials and methods

Six flocks of sheep lying about 3 km from the town were selected and identified using the global positioning system. Their exact position is indicated in figure 1 (areas 1-6).

The shepherds of areas 2, 5 and 6 declared that their sheep always grazed within the same zone, whereas the others (areas 1, 3 and 4) said that in the transhumance period (November-March) their animals are led to a temperate area, about 40 km from the quarry. The mean number of sheep per flock was 190.5 ± 45.4 .

10 sheep randomly selected from each flock and 10 control sheep from a flock bred in an area of about 30 km from the quarry were sacrificed in a slaughterhouse in September-October. A veterinary surgeon conducted ante- and post-mortem examinations to establish the good health of each animal.

The age range of exposed and control animals was 4.0-6.5 years.

From each sheep we collected the cranial tracheobronchial and one middle mediastinal lymph-node, which drain the right apical lobe and the principal and accessory lung lobes, respectively. Lung tissue from these lobes was also collected.

All samples were fixed in 10% formalin for light microscopy (LM) and in paraformaldehyde 4% in 0.1 M phosphate buffer for scanning electron microscopy (SEM). Special care was taken in removing tissue adhering to lymph-nodes before processing.

Half of cranial tracheobronchial and mediastinal nodes, random selected, were employed for measuring the fibre concentration, whereas the other half was employed for histological observations.

The nodes were digested in sodium hypochlorite solution (15-16% free chlorine; Subalpina, Turin, Italy) according to Morgan and Holmes (12) and the residues were filtrated and collected on 0.2 μm pore size Nucleopore filters. Quantification of ferruginous bodies (FB) and naked fibres was done by LM and SEM, using a Zeiss Axiophot (Oberkochen, Germany) and an electron microscope Philips XL-20, (Philips, Monza, Italy) equipped with an energy dispersion spectrometry x-ray analysis (EDAX) apparatus. Tissue specimens were analysed by SEM with the method described by Tuomi et al. (16). Fibers $>1 \mu\text{m}$ in length and $>0.3 \mu\text{m}$ in diameter were identified, sized and counted at a magnification of $\times 5000$.

Results were expressed as mean $\pm$ standard deviation (SD). After variance analysis (ANOVA), data was subjected to Bonferroni's t-test. Significance was established at $p \leq 0.05$.

Results

LM observations did not evidence FB in digested nodes or in histological sections.

SEM analysis of digested lymph-nodes showed some naked fibres, whose X-ray analysis revealed that most of them had the crystallo-chemical features of FE described by Gianfagna and Oberti (8). They ranged from 8 to 41 μm in length and from 0.4 to 1.39 μm in diameter. Their dimensions were similar to those described by Paoletti and co-workers (Paoletti et al., 2000; Rapisarda et al., 2003) in the lung of a housewife from Biancavilla married to a farm worker, who died from pleural mesothelioma. FE fibres were also scattered in histological sections.

No coated FE fibres were observed in digested specimens or in histological sections.

Anthophyllite and man made mineral fibres (MMMF) were discovered in about 3% of samples.

FE fibres were found in all the nodes of exposed animals, but never in those from control sheep. The mean number of fibres, measured as $\times 10^6$ fibres/g dry tissue, ranged from 0.06 ± 0.01 to 0.11 ± 0.05 and was not significantly different among exposed animals. The data regarding fibre concentrations and dimensions in the lymph-nodes of exposed and control animals is reported in table 1.

Discussion

We chose to assess the FE pollution in the farmland measuring the concentration of fibres in tracheobronchial and mediastinal lymph-nodes in sheep habitually grazing at some distance from the quarry with LM and SEM examination.

Sheep lungs are comparable for architecture, volume and respiratory physiological parameters to human lungs (Begin et al., 1981; May, 1970). The sheep model is therefore well suited for dose-response studies to environmental pollutant exposure (Begin et al., 1981; Rapisarda et al., 2005). Sheep have also been employed to study asbestos fibre environmental pollution (Dumortier et al., 2002; McConnochie et al., 1987; Rey et al., 1994).

We studied the tracheobronchial and mediastinal lymph-nodes because they are considered a better indicator of previous asbestos exposure than lung parenchyma: in the latter, the mucociliary and lymphatic systems continuously remove fibres from the lung tissue, thus reducing their concentrations (6), whereas the mineral particles carried from lung alveoli to bronchial nodes accumulate there, turning the nodes into reservoirs of retained material (Gross and Detreville, 1972; Schlesinger, 1985).

Our results seem to demonstrate that a few kilometres from the town there is a certain risk for agricultural workers of inhalation of the dust particles, particularly FE fibres, from the Mt Calvario quarry. Similar results were found by DeNardo and coworkers (2004); they asserted that fiber exposure risk is not confined to the urban area, raising the possibility of hazard to the rural community.

The fibers founds in the nodes were very few compared to those measured in nodes of humans exposed to asbestos (Dodson et al., 1990), but similar to those observed in nodes of non occupationally exposed humans (Dodson et al., 2000).

However, McConnochie et al. (1987) have reported, in the lungs of sheep grazing within 5 miles from an asbestos mine, a tremolite fibers concentration similar to that we noticed in our study.

The presence of a not elevated number of fibers in sheep lymph nodes could be related to: a short time of exposure (maximum 6.5 years); distance from fibers source (minimum 3 Km); low concentration of fibers in house building materials; dispersion of fibers, from Mt. Calvario, with no mechanical alterations so that they still present an aggregation size that does not allow the penetration into respiratory airways.

Conclusions and perspectives

In order to assess the concentration and diffusion of airborne FE fibres in the farmland around the municipal territory, we have used a previously validated sheep model as a biological indicator.

The carried out observations and the laboratory tests show allow us to ascertain a risk of exposure to FE fibres by people living in a FE quarry surrounding.

In particular, obtained results seem to demonstrate that a few kilometres from the town there is a certain risk for agricultural workers of inhalation of the dust particles, particularly FE fibres, from the Mt Calvario quarry.

Once the risk is ascertained, we are planning to focus on a health surveillance program for this category of workers, so that any pathologies deriving from such unexpected exposure can be prevented.

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Table 1. Concentration and size (mean and SD) of FE fibres found in sodium hypochlorite-digested lymph-nodes in exposed and control sheep.

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Control
Concentration x10 ⁶ f/g dry tissue	0.09 ±0.04*	0.11 ±0.05*	0.08 ±0.3*	0.07 ±0.02*	0.07 ±0.03*	0.06 ±0.01*	0 ±0
Fibre length, µm	24.3 ±13.9	23.2 ±12.9	24.1 ±8.6	28.8 ±11.1	26.8 ±10.6	28.6 ±16.8	0 ±0
Fibre diameter, µm	0.87 ± 0.28	0.93 ±0.23	0.86 ±0.35	0.77 ±0.31	0.91 ±0.26	0.85 ±0.41	0 ±0

*p<0.05; analysis of variance (ANOVA) exposed vs. control.

°p<0.05; analysis of variance (ANOVA) exposed vs. exposed.

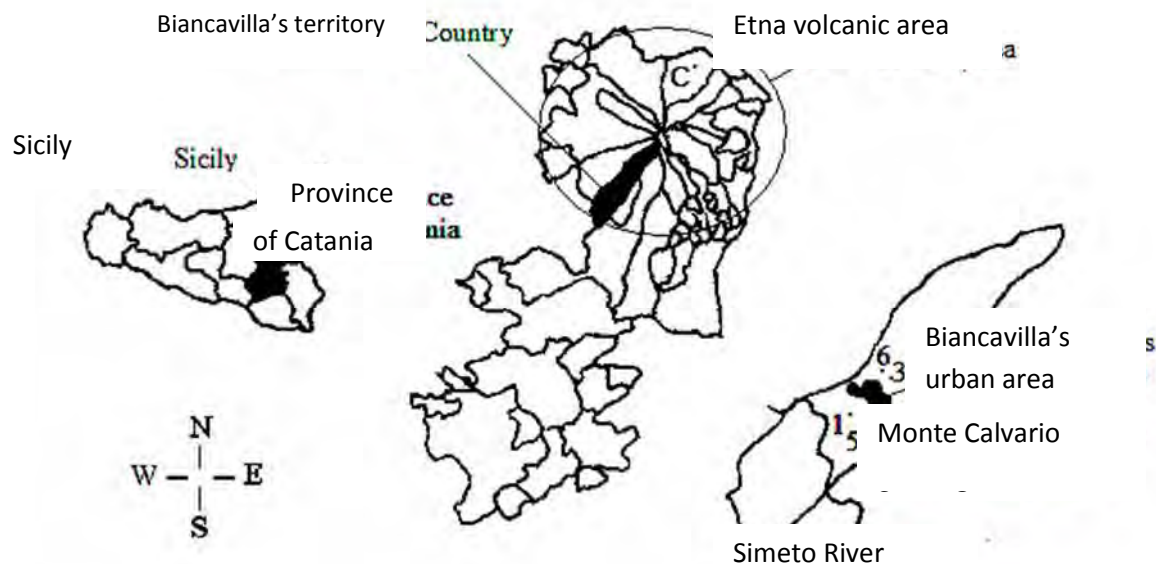


Figure 1. From left to right: map of Sicily; the Province of Catania; the area of Mount Etna (C: the pasture area of the control group); and the territory of the municipality of Biancavilla with the town, the stone quarry and the pastures of the six flocks (1-6).

Noise risk assessment in a modern oil mill plant

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Abstract

High levels of noise usually occur in the oil mill plant because of the machines used to extract extra virgin olive oil. In Italy the Law Decree 81/2008 defined the requirements for assessing and managing noise risk, identifying a number of procedures to be adopted at different noise levels to limit workers exposure. This study aims at evaluating the equivalent and peak noise level inside a modern oil mill plant area. Twenty measurement points were identified inside the oil mill plant area where the machines for olive oil extraction are located (about 200 m²). The instrument used for the measurements was a precision integrating portable sound level meter, class 1, model HD2110L by Delta OHM, Italy. The measured sound levels exceeded the limits allowed by the regulations in all the measurement points inside the working area; values exceeding the threshold limit of 80 dB(A) were recorded coming up to a maximum value of 93.3 dB(A) close to the hammer crusher. The operators involved are obliged to wear the appropriate Personal Protective Equipment.

Keywords: Noise Risk, Oil Mill Plant, Threshold Limit

Introduction

Noise in agriculture is another relevant risk factor to be taken into account in evaluating health and safety of workers (Vallone & Catania, 2013). Excessive noise is a global occupational health hazard with considerable social and physiological impacts, including noise-induced hearing loss (NIHL) (Deborah et al., 2005).

High levels of noise usually occur in the oil mill plant because of the machines used to extract extra virgin olive oil. Directive 2003/10/EC of the European Parliament was enacted on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise). It stipulates an upper average limit of noise exposure of a worker during an eight hours shift of work at 85 dB(A). This level is supposed to inhibit hearing impairments of workers (Moselhi et al., 1979). Even the ILO (International Labour Organization) indication agree with this.

In Italy, the Law Decree 81/2008 defined the requirements for assessing and managing noise risk, identifying a series of procedures to be adopted at different noise levels to limit workers exposure. Excessive noise, in fact, is a global occupational health hazard with considerable social and physiological impacts, including noise-induced hearing loss (NIHL). This study aims at evaluating the equivalent and peak noise level inside a modern oil mill plant area.

Materials and methods

Oil mill plant

The oil mill plant examined in this study was equipped with the following machines: discharge tank, defoliator, washing machine, hammer crusher, six malaxation machines, horizontal decanter, and vertical centrifuge. Two operators controlled the different phases of the process.

Instruments used during the tests

The instrument used in the tests is a precision integrating portable sound level meter by Delta OHM, Italy, model HD2110L (Fig. 1).



Figure 1. HD2110L integrating portable sound level meter by Delta OHM, Italy.

Experimental tests

The oil mill area has an almost rectangular plant with an area of approximately 200 m². Twenty measurement points were located through a square mesh whose sides are orthogonal with respect to the sides of the room (Fig. 2).

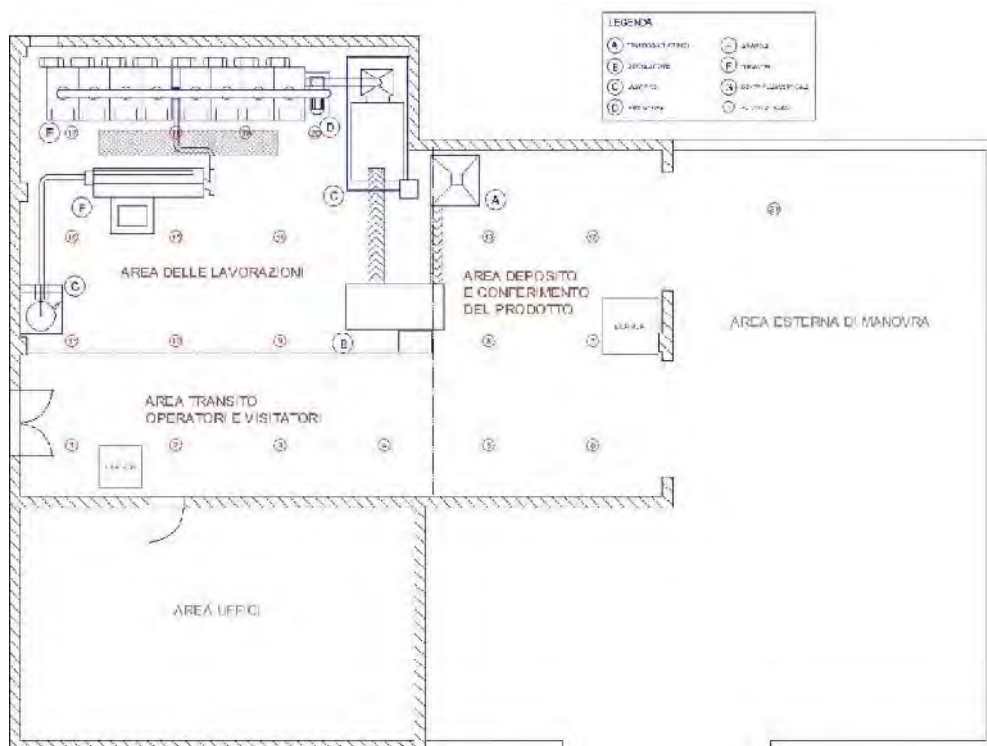


Figure 2. Plan lay out of the oil mill area and measurements points.

The sound level meter was positioned at a height of 1.60 m from the ground with the aid of a tripod; each measurement had a duration of 2 minutes (the case of stationary noise source) and the parameters were analyzed at intervals of 0.5 seconds.

The tests were performed in compliance with EN ISO 9612 and UNI 9432 regulations.

We measured A-weighted time-averaged sound pressure level (L_{Aeq}) and C-weighted peak sound pressure level (L_{Cpk}).

According to article 3 of Directive 2003/10/EC of the European Parliament and article 189 of Italian Law Decree 81/2008, the exposure limit values and exposure action values in respect of the daily noise exposure levels and peak sound pressure are fixed at:

- Lower exposure action values: $L_{EX,8h} = 80 \text{ dB(A)}$; $p_{peak} = 135 \text{ dB(C)}$;
- Upper exposure action values: $L_{EX,8h} = 85 \text{ dB(A)}$; $p_{peak} = 137 \text{ dB(C)}$;
- Exposure limit values: $L_{EX,8h} = 87 \text{ dB(A)}$; $p_{peak} = 140 \text{ dB(C)}$.

where $L_{EX,8h}$ values (occupational noise) is reported to 8 working hours.

$L_{EX,8h}$ value is given by the following equation:

$$L_{EX,8h} = L_{Aeq,Te} + 10 \log (T_e / T_0)$$

where T_e is the effective duration, in hours, of the working day and T_0 is the reference duration equal to 8 hours. In this case T_e was assumed to be 7.5 hours.

Before each series of measurements the instrument calibration was performed applying a sound calibrator. The collected data were downloaded to the PC for further processing.

Results and Discussion

The data obtained by the measurements allowed us to have the equal loudness curves, thereby evaluating the zones with equivalent average sound levels (Fig. 3).

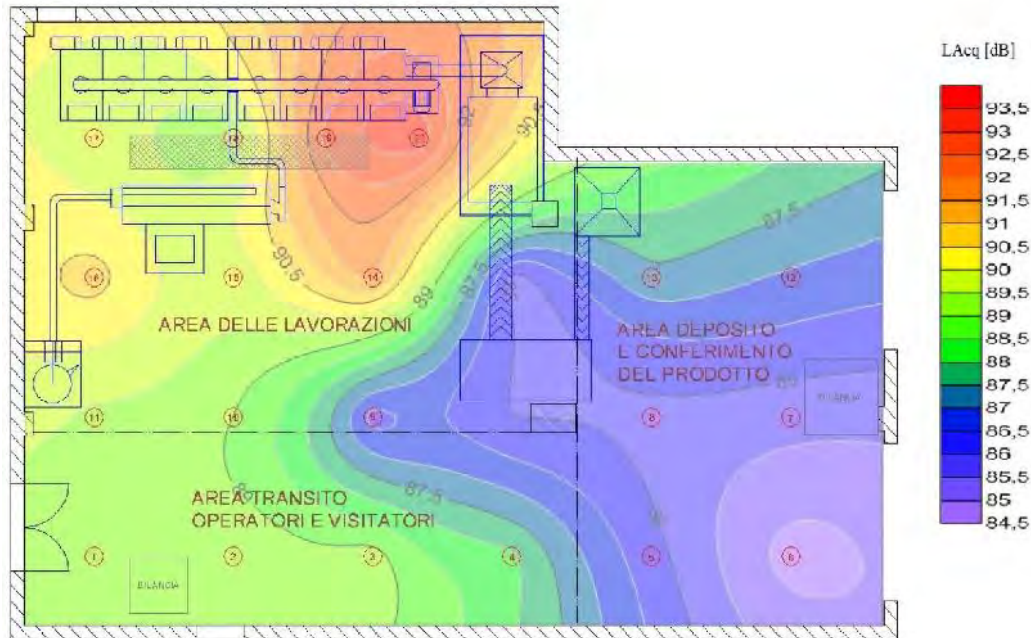


Figure 3. Map of equal loudness curves.

The A-weighted time-averaged sound pressure levels were always higher than the lower exposure action value of 80 dB(A). The minimum noise level was in correspondence of the measurement point number 6 which is located near the storage area, equal to 84.8 dB(A).

The highest value of 93.3 dB(A) was recorded near point number 20, close to the hammer crusher.

Therefore, the highest noise risk for the workers are close to the hammer crusher and the malaxation machines, where the highest noise level was recorded in agreement with the results obtained by Panaro et al. (2005) and Porceddu & Dionigi (2010).

As a consequence, the use of appropriate PPE (Personal Protective Equipment) is required when limits imposed by the regulations are exceeded. In this case, the employer provides workers with personal protective equipment, demanding the use if noise levels exceed 85 dB(A).

With reference to the peak values, neither the exposure limit value equal to 140 dB(C), or the upper and lower action values (equal to 137 dB (C) and 135 dB (C)) are reached or exceeded in any of the measurement points.

In the measurement points number 14, 16, 19 and 20 L_{Aeq} exceeded 90 dB(A); according to the law we are in the presence of dangerous areas where only specialized personnel may access. In all the other measurement points, L_{Aeq} was in the range 85-90 dB(A); therefore it is obliged to use personal protective equipment and carry out an annual audiometric test.

Conclusions

The results show that noise pressure values measured during the test are always higher than the lower action value identified by law, equal to 80 dB(A). In particular, the upper action value equal to 85 dB(A) is reached in all the measurement points located inside the operation area. As a consequence, the use of appropriate PPE is required when limits imposed by the regulations are exceeded.

With reference to the peak values, neither the exposure limit value equal to 140 dB(C), or the upper and lower action values (equal to 137 dB (C) and 135 dB (C)) are reached or exceeded in any of the measurement points.

Acknowledgements

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Model to analyse semi-active suspension system for a tractor cab

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Abstract

Tractor driving causes comfort and spinal problems due to low-frequency vibrations. For these reasons suspension systems have been adopted in order to limit the vibration transmitted to the driver. However, it has been shown that despite the use of traditional devices like suspensions on the axles, on the cab and on the seat, the level of vibration in some operations is higher than the vibration level limit prescribed by the Directive 2002/44 /CE. The vibration may be reduced through semi-active cab suspension system. The purpose of this research is to develop a specific control system for tractor cab semi-active suspensions in order to reduce the level of vibration compared to traditional suspensions. The analysis of the results shows that the designed control produced a reduction in the level of vibrations transmitted to the driver and an increase in the driving comfort.

Keywords: Ride Vibration, Agricultural Machinery, Controlled System

Nomenclature

$2t_f$	Distance between front right suspension and front left suspension
$2t_r$	Distance between rear right suspension and rear left suspension
a	Distance between reference system center and front suspension
b	Distance between reference system center and rear suspension
$[C]$	Damping matrix
c_f	Front shock absorbers damping coefficient
c_r	Rear shock absorbers damping coefficient
$[C_{TOT}]$	Global damping matrix
$[F]$	Linear equation system matrix related to $\underline{v}$
$F_{fr}, F_{fl}, F_{rr}, F_{rl}$	Forces applied by the semi-active systems in the four cab corners
$[K]$	Stiffness matrix
k_f	Front springs stiffness
k_r	Rear springs stiffness
$[L_C]$	Linear equation system matrix related to $\underline{\dot{q}}$
$[M]$	Mass matrix
$\underline{q}$	Degrees of freedom of the system
$\underline{u}$	Forces provided by the semi-active suspension system
$\underline{v}$	Speeds and displacements of the original cab suspension element.
z	Heave displacement
$\dot{z}_{susp,mean}$	Weighted average of the cab corners speed
θ	Pitch displacement
$[A]$	Linear equation system matrix related to $\underline{u}$
ρ	Roll displacement

Introduction

Since the early 60's, most of agricultural machinery manufacturers have begun to install systems able to reduce the whole body vibration (WBV). This is due to the recognition of comfort problems and possible spinal problems caused by low-frequency vibration that arise during the drive of an agricultural tractor. For example the transmission of vibrations to the driver can be reduced with front axle, cab and seat suspensions. However, it has been shown that despite these devices, the level of vibration in some conditions is higher than the exposure limit prescribed by Directive 2002/44 /CE (Scarlett, Price & Stayner, 2007).

Therefore, the introduction of more effective suspensive systems than those currently mounted on tractors is necessary, such as semi-active suspension. These suspensions are able to adjust their damping characteristics depending on the load which they are subjected to (Braghin, Resta & Sabbioni, 2007). The implementation of semi-active suspension in agricultural machinery is a fairly recent event, in fact tractor manufacturers have invested in the development of this technology on high-power tractors only in the last decades.

A control theory widely used on this type of suspension is the Skyhook, a two states control that modifies the damping coefficient of a shock absorber according to the speed at the ends of a suspension (Savaresi, 2010).

However, the Skyhook algorithm has been originally designed for a single degree of freedom system, while the cab is multi degree of freedom system.

The purpose of this research is to develop a specific control system for tractor cab suspensions in order to improve the vibration level compared with passive suspensions.

Materials and methods

The research has been conducted using as a model of study the cab of a tractor with 12.9 L engine size and 441 kW engine power. The weight of the whole tractor is 22126 kg and the cab weight is 1000 kg, estimated from bibliography (Mattetti, 2012).

The tractor is originally equipped with a 4 point cab suspension system with conventional springs and dampers. Therefore, the cab has been modeled as a rigid body in which semi-active suspension systems are installed at the four corners in order to simulate the cab behavior during the ride (Figure 1). Consequently, the cab model has three degrees of freedom: heave (z), roll (ρ) and pitch (ϑ).

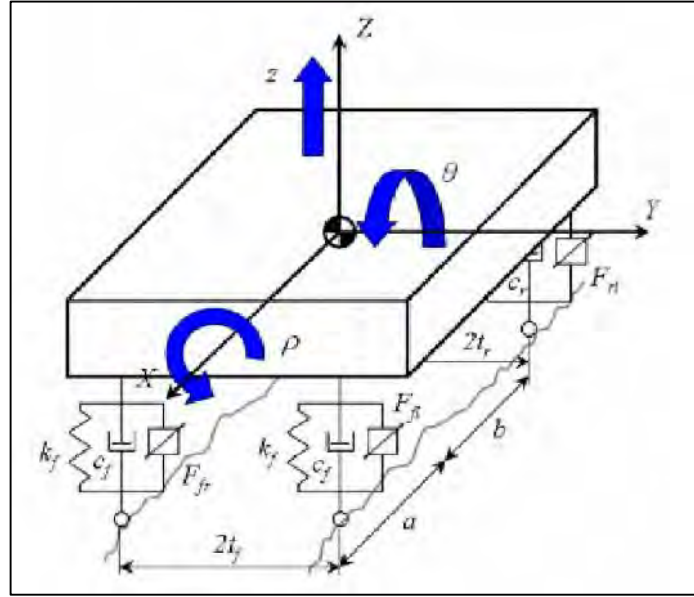


Figure 6. Cab model (Braghin, Resta & Sabbioni, 2007)

The equation of motion of the obtained system is shown in equation 1

$$[M]\ddot{\underline{q}} + [C]\dot{\underline{q}} + [K]\underline{q} = [A]\underline{u} + [F]\underline{v} \quad (\text{eq. 1})$$

Where $[M]$, $[C]$ and $[K]$ are the mass, the damping and the stiffness matrices, respectively. The eight components vector $\underline{v}$ contains the speeds and the displacements of the original cab corners experimentally measured on the ISO 5008 “smooth” test track at 12 km/h (ISO, 2002). Moreover, $\underline{q}$ is a three components vector that contains the degrees of freedom of the system and $\underline{u}$ is a four components vector that contains the forces provided by the semi-active suspension system. The vector $\underline{u}$ is calculated through a modified Skyhook algorithm. First, the values for the damping coefficient have been calculated with the Equations from 2 to 7, being C_{zz} , $C_{\rho\rho}$ and $C_{\theta\theta}$ the diagonal elements of the $[C]$ matrix, respectively.

$$C_z = C_{zz,Max} \text{ if } \dot{z}(\dot{z} - \dot{z}_{susp,mean}) \geq 0 \quad (\text{eq. 2})$$

$$C_z = C_{zz,Min} \text{ if } \dot{z}(\dot{z} - \dot{z}_{susp,mean}) < 0 \quad (\text{eq. 3})$$

$$C_\theta = C_{\theta\theta,Max} \text{ if } \dot{\theta} \neq 0 \quad (\text{eq. 4})$$

$$C_\theta = C_{\theta\theta} \text{ if } \dot{\theta} = 0 \quad (\text{eq. 5})$$

$$C_\rho = C_{\rho\rho,Max} \text{ if } \dot{\rho} \neq 0 \quad (\text{eq. 6})$$

$$C_\rho = C_{\rho\rho} \text{ if } \dot{\rho} = 0 \quad (\text{eq. 7})$$

Then, the obtained values C_z , C_θ and C_ρ have been included as elements of the diagonal matrix $[C_{TOT}]$. Subsequently, equations 8 and 9 have been used to create a relationship between vector $\underline{u}$ and the matrix $[C_{TOT}]$.

$$[C_{TOT}] = [C] + [A][L_C] \quad (\text{eq. 8})$$

$$\underline{u} = -[L_C]\dot{\underline{q}} \quad (\text{eq. 9})$$

$[L_C]$ is a four rows and three columns matrix and its elements have been obtained by solving the equation 8. One can note that equation 8 is an underdetermined system of linear equations. Consequently other conditions on the elements of the $[L_C]$ matrix have been set:

- $L_{11}=L_{21}=L_{31}=L_{41}$: in order to set the same force contribution on all four corners to limit the vertical displacement
- $L_{12}=L_{22}$ and $L_{32}=L_{42}$: in order to set the same force contribution on the same transverse axis to limit the pitch.
- $L_{13}=L_{33}$ and $L_{43}=L_{23}$: in order to set the same force contribution on the same longitudinal axis to limit the roll.

Then the equation 1 could be reformulated like equation 10

$$[M]\ddot{\underline{q}} + \begin{bmatrix} C_z & 0 & 0 \\ 0 & C_\theta & 0 \\ 0 & 0 & C_\rho \end{bmatrix} \dot{\underline{q}} + [K]\underline{q} = [F]\underline{v} \quad (\text{eq. 10})$$

Then the cab model has been modeled with the *Power Oriented Graphs (POG)* technique (Zanasi, 2010) and it has been simulated with the software *MATLAB Simulink (Mathworks, Natick, MA)*.

The accelerations obtained from the simulations have been corrected through frequency weighting function according to the ISO standard 2631-1(ISO, 1997), because the human body has different sensitivity to different vibration frequencies. In order to evaluate the benefits of the semi-active suspension system, a comparison has been made between the simulation outputs obtained with the semi-active suspension system activated and the outputs obtained with the same model with the semi-active suspension system deactivated. This has been carried out setting the vector $\underline{u}$ equal to 0.

Results

The graphs in Figure 2 show that there is an acceleration amplitude peak around the 2 Hz frequency. The roll acceleration values are very low, because of the characteristics of the simulated test track and the tractor was running straight.

A big reduction in the accelerations in the range of frequencies between 1 Hz and 5 Hz has been obtained. On the other hand, a slight increase in the acceleration is observable for frequencies higher than 5 Hz. Moreover, the cab equipped with the semi-active suspension system showed a reduction in weighted acceleration of 10% compared with the cab devoid of this system.

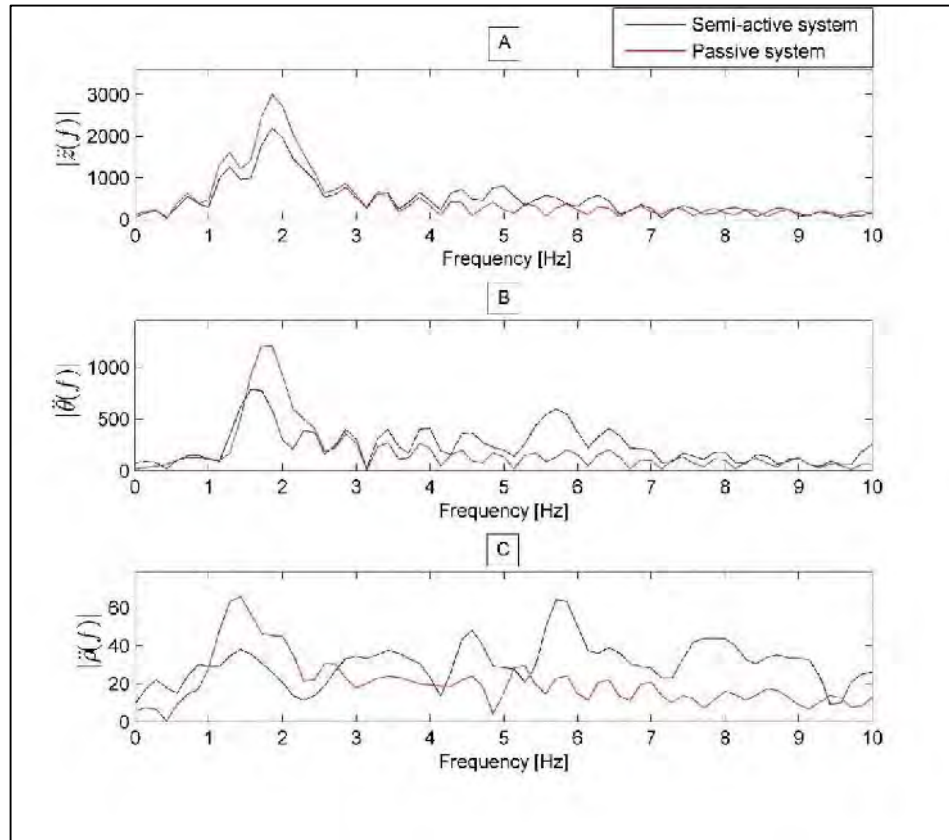


Figure 7. Heave acceleration FFT (a) pitch acceleration FFT (b)

Conclusions

Comfort spinal problems caused by low-frequency vibrations that arise during the drive of an agricultural tractor have been a subject of study over the last decades. A tractor cab equipped with semi-active suspensions is a solid solution for these problems. In the paper a specific control system for tractor cab semi-active suspensions has been designed. The analysis of the results show that the designed control applied to this cab suspension system equipped with semi-active suspension produced a reduction in the vibrations transmitted to the driver and an increase in the driving comfort. A possible future development of this research is the design of a real-time control system based on the control presented in this paper.

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TOPIC 5

“Occupational Health”

Evaluation of safety aspects on a machine for nuts harvesting

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Abstract

The great part of the machine on the market for the collection of the nuts is characterized by a suction member placed over a cart with wheels or tracks, pulled by a tractor. This solution, although effective and efficient in rational cultivation with planting distances designed specifically to allow the passage of agricultural vehicles, misses instead possibility of use in spontaneous mountain hazel, without a regular planting distance. Moreover, the steep slopes that usually occur in wild hazel, make impractical the manoeuvres with the possibility of overturning the tractor vehicle and the carried truck.

Recently were born, also in the traditional way, simple mechanical solutions which consist in placing the suction member for harvesting, above small self-propelled trucks. Recent research has been conducted to evaluate the safety of the operations of harvesting of nuts in sloping land related aspects in noise and roll-over.

In this study was evaluated, in addition to efficiency and to working hours, safety aspects of a machine made by a local craftsman, but that has a commercial success in the Etna area, of considerable importance for the Hazelnuts in Sicily and for the Nebrodi park. The machine is characterized by a vacuum system placed on a self-propelled crawler to collect the nuts in sloping land and with soils corrected with very close terraces and not easy to reach for the traditional mechanization. In particular, attention was focused to aspects of noise level and to stability, evaluated by a tiltable platform.

Moreover will be assessed the principle health risks due to biomechanical overload (Work related Skeletal Muscle Disorders), will be analysed through the indices risk assessment of increased use, with particular regard to the operators involved in the harvesting and the manual handling of the product.

Data analysis and evaluation of safety aspects will identify the machine's ability to meet the harvesting operations and any limitations in terms of safety.

Keywords: Safety, Harvesting, Nuts.

Introduction

The production of nuts, in Italy, comes from crops characterized by variable density of planting, often without regular plantation, from steep slopes and rough terrain conditions.

These factors make difficult and dangerous for the operators the use of mechanization in all stages of cultivation, but especially during harvesting. Other factors that affect cultivation are represented by the cost of labor and the lack of economic convenience. Operators, in these areas, rarely uses for harvesting traditional machines available on the market picking machines that aspirate, towed or self-propelled. This kind of machine reduce health hazards and are useful solution (Ghiotti, 1989).

The harvesting aspirating machines, used in awkward areas, are towed.

These machines have small dimensions and a low weight compared to all other machines, allowing use with tractors of small and medium power.

However, the first major obstacle to the use of these harvesters is represented by the presence of the tractor that operate under conditions of high slopes and terraces in addition with risk of roll-over problems. Moreover the reduced interfile are incompatible with the overall mechanization.

So one of the things that most penalizes the labor productivity under these conditions is to find the machines for awkward areas.

So was subjected to study an aspirating compact machine, capable of being transported by simple means such as small tracked pallet.

Methods

Aspects of rollover

Experimental tests were conducted on a suction machine of particularly reduced dimensions assembled to a mini-transporter crawler, schematized in figure 1. The mass and small size of the innovative machine have been selected and designed with the intention to operate in poor areas, characterized by steep slopes and rugged conditions.



Fig.1: Schematic design of the tested machine.

The overall dimensions of the transpallet were 1.10 m x 2.00 m x 1.75 m of height, the mass was 330 kg, and the load capacity was 500 kg. The technical features of the aspiration device are shown below in Table 1.

Table 1. Technical features of the machine

Total size (m)	length 1,5 - width 1,1 - height 1,4
Mass (kg)	150
Engine	Internal combustion
Mode of leaf removal	a roller with interchangeable cylinder
Suction hose	maximum length 15.00 m
Storage product	movable box 0,54 m x 0,36 m x 0,33 m (h)

The machine was tested using, where possible, established methods and recognized internationally.

To determine the center of gravity was used, the procedure described in Standard ISO 789-6:1982 “Agricultural tractors – Test procedures – Part 6: Centre of gravity”.

For stability tests on an inclined plane has adapted the norm UNI ISO 22195-1/2 “Carrelli industriali: verifica della stabilità”.

Aspects of noise

For the noise evaluation we used the integrator photometer Brüel & Kjær model with responded ISO 9432. The equivalent weighted sound level in curve A of noise exposure of workers during the eight working hours;

1. The peak level.

$$L_{EP,d} = L_{Aeq,Te} + 10 \log\left(\frac{T_e}{T_0}\right) \text{ (dB(A))} \quad (1)$$

where,

$$L_{Aeq,Te} = 10 \log \left\{ \frac{1}{T_e} \int_0^{T_e} \left[\frac{p_a(t)}{p_0} \right]^2 dt \right\} \quad (2)$$

T_e represented the daily duration of worker exposition to noise;

T_0 represented the duration of working turn of 8h;

P_a represented the acoustics instantaneous pressure weighted in curve A, expressed in [Pa];

P_0 represented the pressure of 20 μ Pa audibility threshold.

$$L_{peak}(dB) = 10 \log \left(\frac{p_{peak}^2}{p_0^2} \right) \quad (3)$$

Where, P_{peak} defined come acoustic instantaneous an weighted pressure. This value had the purpose to quantify the characteristics of impulsive sound event because they represent an additional risk factor in the evaluation. The risk bands defined in the abrogated law were:

- $L_{EP} > 90 \text{ dB(A)}$ o $L_{picco} > 140 \text{ dB (A)}$
- $L_{EP} > 85 \text{ dB(A)}$ e fino a 90 dB(A)
- $L_{EP} > 80 \text{ dB(A)}$ e fino a 85 dB(A)
- fino a 80 dB(A) di L_{EP}

This bands procured rights, obligations and duties from the prevention figures, mentioned in the norm.

The equivalent measured levels (at least 3 measurements per station), were processed: the data series of equivalent collected levels, was represented through its arithmetic average, and the variability degree (data attitude to arrange around the average value) through the standard deviation:

$$\sigma = \left[\sum_{i=1}^n (L_{Aeq,T} - L_{Aeq,TM})^2 / n \right]^{1/2} \text{ [dB(A)]} \quad (4)$$

Where:

$L_{Aeq,TM}$ = level average equivalent value, calculated on n data.

With L. D. 626/94, evaluation methodologies didn't change, compared to the previous legislation until the Legislative Decree 195/06, that integrated the Decree of 1994 with the Title V Bis. The Title V Bis, replaced by the daily noise exposure level (LEX, 8h): [dB (A) refers to 20 Pa]: defined by international standard ISO 1999: 1990, section 3.6. It was referring to all kind of noise at workplace, including impulsive noise;

$$LEX, 8h = L_{Aeq, Te} + 10 \log \left(\frac{T_e}{T_0} \right) \quad [dB(A)] \quad (5)$$

From the point of view of calculation there was no difference between the LEP,d and the LEX, 8h; while a diversity observed with the peak level that wasn't measured as L_{peak} in linear form but as a peak acoustic pressure (p peak), that is the maximum value of the instantaneous acoustic pressure frequency weighted "C";

$$L_{picco}(dB) = 10 \log \frac{p_{peak}^2}{p_0^2} \quad [dB(C)] \quad (6)$$

The introduction of Title V Bis went to change even the previous risk bands, imposing new exposition limits:

LEX,8h = 87 dB(A) ppeak = 200 Pa (140 dB(C) related to 20 µPa).

Higher action values:

LEX,8h = 85 dB(A) ppeak = 140 Pa (137 dB(C) related to 20 µPa).

Lower action values:

LEX,8h = 80 dB(A) ppeak = 112 Pa (135 dB(C) related to 20 µPa).

Per quanto concerne la valutazione del rischio per il sistema mano-braccio si applica la norma UNI EN ISO 5349-1:2004 (versione in lingua italiana della norma ISO 5349 del 1986, aggiornata nel 2001 dalle EN ISO 5349-1/2).

Aspects of vibration to the hand-arm system

With regard to the assessment of risk to the hand-arm system has been applied to the UNI EN ISO 5349-1: 2004 (Italian version of ISO 5349 in 1986, updated in 2001 by EN ISO 5349-1 / 2) .

Aspects of efficiency and to working hours

For testing the experimental methodology used is that given by CIOSTA (Commission Internationale de l'Organisation Scientifique du Travail en Agriculture): in particular the work time are classified in accordance with Recommendation AIGR. For analysis of the working times tables we were used chronometric precision for the relief of the times.

Following the analysis of harvest times, repeated for a few hours on several plots with different characteristics between them, with variable gradients from 24% to 35% it is determined the amount of hazelnuts gathered in one hour of work.

Aspects of health risks due to biomechanical overload

The study, in this early stage, concerns the analysis and risk assessment of biomechanical overload in the hazelnuts cultivation. This is an multi-tasks complex analysis in an annual

cycle, in which the seasonal characteristic of the agricultural sector will greatly influence the work and therefore the workers exposure to the risk.

Furthermore in mountain *corilicoltura* many of the cultivation operations, which generally are mechanized, are performed manually constituting a major source of physical overload.

The first phase has focused on the identification of hazelnuts processing, by the plant at harvest and post-harvest, with the subsequent decomposition of the work in the elementary stages.

In the slope less relevant, where it was possible to perform the collection through machine facilitator, the operation of the worker involved in the collection is reduced, in this case, to the only movement of the aspiration tube. Were carried out, therefore, harvesting tests, employing different types of handles for the aspiration tube to verify which provides greater comfort.

For gathering was carried out an initial risk assessment of biomechanical overload due to the repetitive motion, using the OCRA checklist.

Results

Aspects of rollover

Regarding the tests for determining the center of gravity, the coordinates which identify its location have been identified with the method of successive weighings, and with the longitudinal inclination of the machine by an angle of 20 degrees so as to cause a mass transfer on the axle on the ground.

The recorded values are reported in Tab. 3 where (x) identifies the distance of the center of gravity from the plane passing through the center of the conductor axle (rear sprocket), (y) indicates the distance from the vertical median plane (positive to the right) and (z) locates the center of gravity height from the ground.

Table 3. Coordinate position of the center of gravity of the prototype.

Coordinate	Value (m)
x	0,444
y	0,09
z	0,583

Regarding the tests for determining the stability on an inclined plane, in table 4 are shown the values of stability carried out, in the month of January 2015 at the CRA-ING of Treviglio, in static conditions and with any machine discharge collected.

It assessed whether the condition without operator, both the one with the possible operator on the platform through a ballast placed on a stand on the platform one meter high. Therefore, such circumstances must be properly considered when operating under real conditions, with the machine running and operator led.

The test was repeated in three positions, the first with the longitudinal axis of the machine parallel to the tilting axis of the plane (fig.4), the second with the longitudinal axis of the machine perpendicular to the tilting axis of the plane (fig.5) and the third with an angle such that the center of the wheel of the front axle aligned rearly with the center of the axle result parallel with the tilting axis of the plane .

All configurations have been repeated for both sides.

The results are reported in table 4 where appears the different level of stability between right and left side due to the decentering of the center of gravity with respect to the longitudinal axis. It is possible to note that the presence of the operator reduces the stability of the vehicle on a slope.

Table 4. Slope values to which you record the lifting of the track.
Slope to the lifting of the track (°)

	WITHOUT OPERATOR	WITH OPERATOR
Frame lined	30,8 (left) / 26,4 (dx)	26,8 (sx) / 23,9 (dx)
Transverse frame	26.4 (down) / > 35 (uphill)	32,6 (down) / 21,6 (uphill)
Slanting frame	29 (left) / 33 (right)	25,1 (sx) / 28,5 (dx)

Aspects of noise

As regards the reliefs related to the sound pressure, in a measurement time of 30 minutes, was detected 84 (Leg (A)) in the transfers, in a measurement time of 5 minutes, 94.6 for the harvesting phase of the hazelnuts with engines running close to the machine, and 77.0 at the end of the aspiration tube for a time of 120 minutes.

Aspects of vibration to the hand-arm system

The assessment tests of the hand arm system made during the transfer in the field of the machine showed a maximum Aw sum (m / s²) equal to 15,00 for a time of 60 minutes, while in the phase of hazelnuts harvesting sensors have highlighted a Aw sum (m / s²) equal to 2.40 for a time of 60 minutes. Therefore, the A (8) is equal to 5.37.

Aspects of efficiency and to working hours

The site collection organized with the prototype at the Sicilian companies reported a labor productivity of 21 kg / h with one operator, compared with 8.5 kg / h of the traditional (manual harvesting), then with productivity gains of 2,5 times. Ultimately, the same amount of hazelnuts harvested with the aid of the prototype with two workers, requires collection of traditional 5 employees.

In a traditional site collection manual, an operator (usually the labor costs in the collection phase is female) has an hourly capacity in average value of about 8.5 kg /h, which corresponds to about 60 kg /day. So the same amount of hazelnut harvest "mechanically" with 2 people, need to "manual" of 5 people.

Aspects of health risks due to biomechanical overload

Harvesting tests were made using different types of handles for the suction hose to verify which provides greater comfort. The operator, who often works on his knees, according to its experience, choose whether to carry out the gathering with one or both hands.

The harvest is characterized by a high frequency of gestures and by continuous pinch of the fingers. In pending the operator, if he works standing, bend less his back keeping the arms under the shoulder height.

In less sloping land, the operator curve over his back to pick the fruit, working with his arms at shoulder level. The stereotypy is high because are always repeated the same actions.

The force required for harvesting is negligible, but the displacement of the bucket, which gradually fills up, requires gradually more and more effort to be reckoned in the risk calculation.

From risk assessment through OCRA checklists, the manual harvesting is within the viola range, in which there is a real risk of biomechanical overload.

The tests conducted with the aspiration machine showed some employed handles do not ensure a grip smoother. Moreover, the limited length of the aspiration tube, forces the worker, even in this case, to work with hunched back. Checks showed, also, that the handles that can be contested with both hands, with ergonomic handle (soft and non-slip), associated with work gloves that help grip, are preferred over other solutions. The movement of the tube provides static ports of the hand and arm movements that never get to reach extreme postures. Also in this case always repeat the same actions. The force required for the collection is relative to the weight of the tube. From evaluation through checklists OCRA, funding through facilitator is within the range of average risk.

Conclusions

The prototype developed in this work is proposed as a possible solution to the mechanization of harvesting the nuts in soils with planting distances and irregular with slopes. On the occasion of the technical evaluation carried out in November 2014, it looked at whether its size that were contained; the steering angle that thanks to the tracks and to the hydraulic transmission is reduced.

In the same survey it was verified the suction capacity of hazelnuts. The ability to manage slopes found objective evidence during the tests conducted at the Laboratory of Treviglio the CRA-ING at which the car was conducted in the month of January 2015.

The checks carried out on the prototype have therefore confirmed the efficiency of the machine in its ability to do the work of aspiration, not the high acoustic impact and rollover resistance to the slopes in the study.

The harvesting through facilitator, as well as to significantly increase the capacity to collect, significantly improves working conditions. It appears, in fact, a significant reduction in the risk of biomechanical overload compared to manual harvesting mainly due to better posture of the back and arms. The presence of an ergonomic handle also reduces the effort for the handling of the suction tube. The possibility of alternation in the operations of collection is, also, a further advantage to be taken into consideration.

Acknowledgments

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Safe in the field: a project for training and integration of foreign agricultural workers

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Abstract

The project "Safe in the Field", funded by the Lazio Region and activated by Department of Science and Technology for Agriculture, Forestry, Nature and Energy and "Innovation & Resources" Ltd, was launched September 15, 2014 and ended March 14, 2015.

The first phase of the project was a research regarding the training needs for workers in the farms of Lazio Region. Subsequently training courses were provided, each lasting 10 hours, per groups of workers from different nations (Italy, India, Romania), with the presence of native tutors in the classroom and the availability of educational materials in language.

One of the aims of the research is to understand the relationship between risk perception among farmers and the main risk factors to which they are exposed. Furthermore to investigate the influence of the training in risk perception in agriculture.

The research regarding the training needs for workers was done by means of a study on distribution of different crops in the region, a study on injuries and occupational diseases in agriculture (Lazio) and a questionnaire submitted to a sample of farms.

As it regards the research on risk perception, the data collection was made possible thanks to the use of a questionnaire designed to investigate the perception of risk that was given to a sample of 99 agricultural workers at the beginning and at the end of the courses.

The results of the project consist in training of agricultural workers. A product of the project was the site <http://ergolab.wix.com/sicurincampo> that provides a platform for the support of teaching materials for work health and safety training for farmers (training materials in 5 languages).

A previous research from the same Authors showed that the perception of risk is related to having attended training courses, but those who report having attended safety courses do not always enact safe behavior.

While we cannot draw conclusions about the behavior of workers after attending the course, the analysis of the questionnaires shows a clear improvement in the perception of risk.

Keywords: Training and Information, Foreign Workers, Safety And Health

Introduction

The project "Safe in the Field", funded by the Lazio Region and activated by Department of Science and Technology for Agriculture, Forestry, Nature and Energy (University of Tuscia, Viterbo, Italy) and "Innovation & Resources" Ltd (Rome, Italy), was launched September 15, 2014 and ended March 14, 2015.

The first phase of the project was a research regarding the training needs for workers in the farms of Lazio Region. Subsequently training courses were provided, each lasting 10 hours, per groups of workers from different nations (Italy, India, Romania), with the presence of native tutors in the classroom and the availability of educational materials in language.

One of the aims of the project was to understand the relationship between risk perception among farmers and the main risk factors to which they are exposed.

The European Agency for Safety and Health at Work (EU-OSHA) defines risk "the likelihood that a hazard will actually cause its adverse effects, together with a measure of the effect". This is a probabilistic concept, not indicating the conditions or factors that determine or contribute an occurrence. A linguistic definition of risk is a "possibility of suffering harm related to the circumstances as far as is predictable" (www.treccani.it). This definition introduces the dimension of knowledge and perception: the damage takes place for the occurrence of circumstances that could be expected in the case of knowledge and perception of their negative potential effects. Knowledge of risk affects the perception, but this is due to a subjective dimension that is related to cognitive, organizational, cultural and emotional factors. As evidenced by Slovic it usually results in a harmful discrepancy between the subjective perception of risk and its objective evaluation (Slovic, 2000). An assessment can only be based on knowledge, but be carried in such a way so as not to lead to an underestimation of risk causing an inadvertent exposure or an overestimation of risk that would cause panic and inability to make decisions (Lavanco, 2003). In both cases, there is an increase of probability of a "mistake", that means a wrong answer to a condition of adaptation; cognitive "dysfunctions" happen, with an alteration in the perception of risk; therefore to remedy it is necessary to identify the environmental, psychological and behavioral causes (Marino et al, 2010).

The perception of risk is the result of a very broad range of factors, primarily cognitive, emotional and socio-organizational (Antonucci et al, 2012). Unfortunately there is not always a consistent perception of risk between operators. The overestimation or underestimation of risk are problematic. Both have serious consequences on people's ability to manage risk properly from the point of view of prevention.

An objective of the research is to investigate the influence of the training in risk perception in agriculture.

Methods

The research regarding the training needs for workers was done by means of a study on distribution of different crops in the region, a study on injuries and occupational diseases in agriculture (Lazio) and a questionnaire submitted to a sample of 60 farms.

As it regards the research on risk perception, the search tool that we delineated is a questionnaire consisting of 25 items to be answered on a scale from 1 (poor / no effect) to 5 (good / relevant). The main issues were: the risk due to tractor overturning; the exposure to noise and vibration; the chemical risk; ergonomics (posture, handling of heavy loads and handling of low loads at high frequency); the use of personal protective equipment; information and training.

The questionnaire was submitted to a sample of 99 agricultural workers at the beginning and at the end of the courses. The collected data were analyzed with software Excell[®].

Results

As it regards the training needs for workers, the knowledge of the working context is very important. The main characteristics of agriculture in Lazio Region are:

- the extreme "pulverization" of farms;
- the extreme "polarization" of the size distribution of farms (90% less than 5 ha, 0.7% more than 50 ha);
- the farm fragmentation (47% one body farms, 9.8% more than 5 bodies);
- the scarcity of processing industries (often by family);
- small farms often employ family labor (in many cases made by elderly or figures with

poor alternative employment).

The main agricultural sectors are (Carbone et al, 2004): sheep and goat (2nd in Italy for milk, 3rd for meat); vegetable productions (8% gross marketable production in Italian horticulture); actinidia (Latina province) (1st in Italy); hazelnuts (Viterbo province) (2nd in Italy); olive oil; sheep cheese; wine production.

Important factors consist in the increasing number of foreign workers (table 1) and in educational disadvantage of workers and farm owners (figure 1) (ISTAT, 2010).

Table 1. Total workforce, number of people for citizenship (Lazio)

Province	Italian	Foreign from EU country	Foreign from extra EU country	Total
Viterbo	60420	1101	566	62087
Rieti	27488	433	210	28131
Roma	67452	1626	995	70073
Latina	64132	3203	4287	71622
Frosinone	73419	193	774	73690
TOTAL	292911	6556	6832	305603

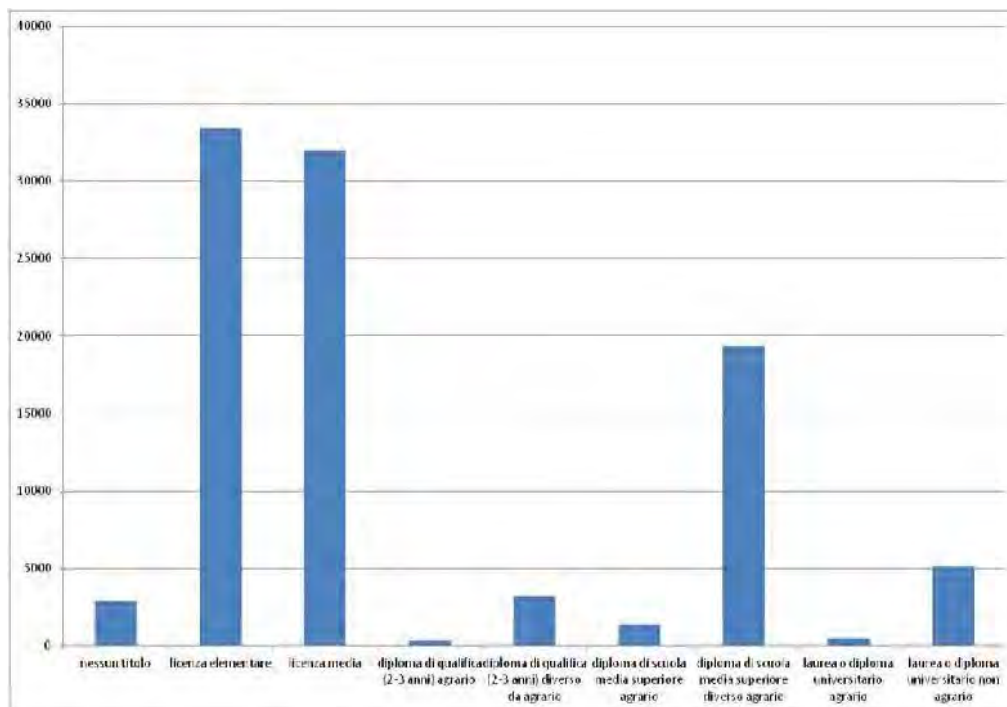


Figure 1. Qualification of farm manager (Lazio)

During the last years the trend of work injuries in regional agriculture is decreasing (figure 2), but fatal accidents are quite constant (figure 3) (INAIL, 2014).

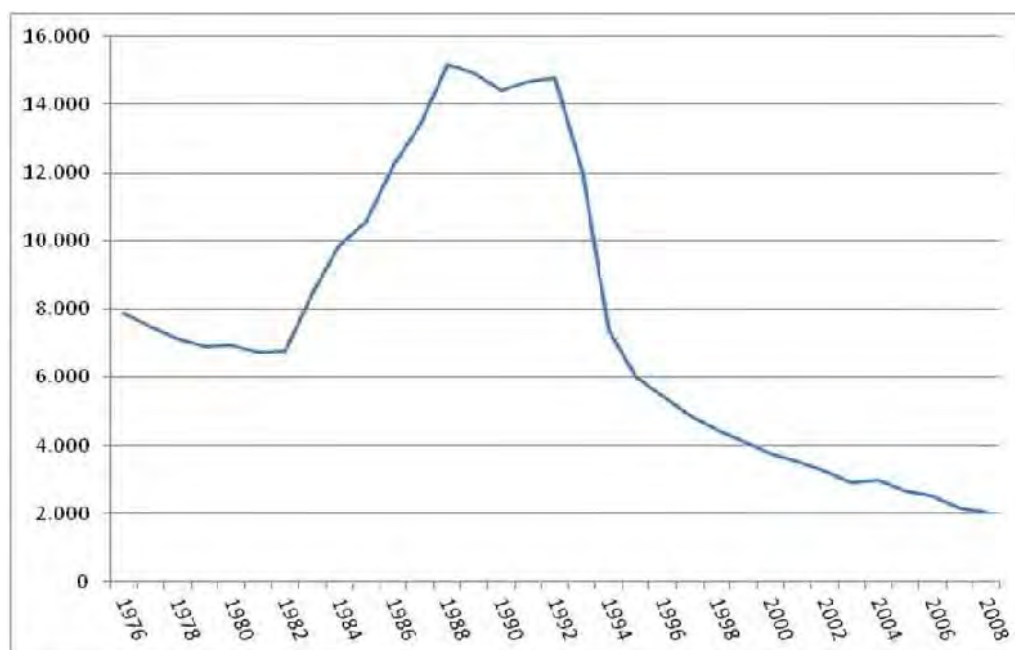


Figure 2. Accidents occurring in each year and reported to INAIL in agriculture (Lazio)

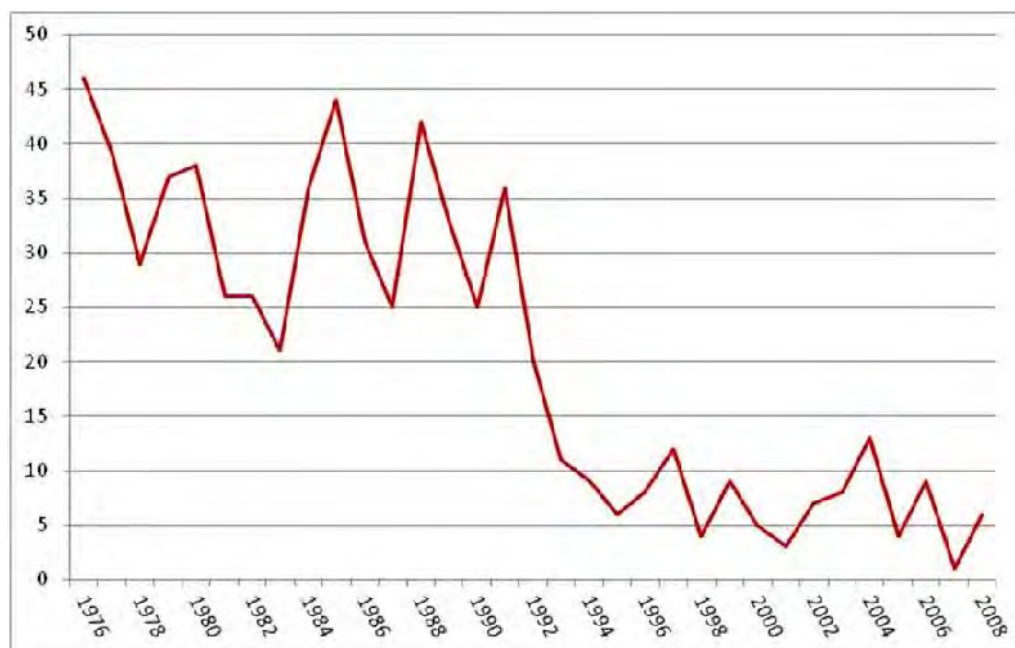


Figure 3. Fatal accidents occurred in each year and reported to INAIL in agriculture (Lazio)

Very different is the trend for occupational diseases (table 2) (INAIL, 2014) for which a surge of complaints of suspected occupational diseases can be observed (especially for female workers). The decline of traditional occupational diseases, such as hypoacusis, joins the growth of diseases related to biomechanical overload of the musculo -skeletal system in its broadest sense.

Table 2. Complaints of occupational diseases for birthplace, sex, year (Lazio)

Luogo di nascita	Genere	Anno di protocollo									
		2009		2010		2011		2012		2013	
Italia	Maschi	1,108	79,71%	1,196	74,15%	1,325	74,11%	1,276	70,54%	1,591	72,58%
				7,94%		10,79%		-3,70%		24,69%	
	Femmine	282	20,29%	417	25,85%	463	25,89%	533	29,46%	601	27,42%
				47,87%		11,03%		15,12%		12,76%	
	Totale	1,390	100,00%	1,613	100,00%	1,788	100,00%	1,809	100,00%	2,192	100,00%
				16,04%		10,85%		1,17%		21,17%	
Unione Europea (esclusa Italia)	Maschi	10	58,82%	22	56,41%	21	61,76%	31	77,50%	40	64,52%
				120,00%		-4,59%		47,62%		29,03%	
	Femmine	7	41,18%	17	43,59%	13	38,24%	9	22,50%	22	35,48%
				142,86%		-23,53%		-30,77%		144,44%	
	Totale	17	100,00%	39	100,00%	34	100,00%	40	100,00%	62	100,00%
				126,47%		-12,82%		17,55%		55,00%	
Extra Unione Europea	Maschi	20	60,61%	39	76,47%	37	75,51%	32	76,19%	40	66,67%
				95,00%		-5,13%		-13,51%		25,00%	
	Femmine	13	39,39%	12	23,53%	12	24,49%	10	23,81%	20	33,33%
				-7,69%		0,00%		-16,67%		100,00%	
	Totale	33	100,00%	51	100,00%	49	100,00%	42	100,00%	60	100,00%
				54,55%		-3,92%		-14,29%		42,86%	
Non determinato	Maschi	0	-	0	-	0	-	0	-	0	-
				-		-		-		-	
	Femmine	0	-	0	-	0	-	0	-	0	-
				-		-		-		-	
	Totale	0	-	0	-	0	-	0	-	0	-
				-		-		-		-	
Totale		1,440		1,703		1,871		1,891		2,314	
				18,26%		9,86%		1,07%		22,37%	

The above figures are even more alarming when considering the reduction of the workforce that has taken place in recent years (-30% from 2000 to 2010).

One of the objective of the project is the training of agricultural workers. Four courses were organized in the period January - February 2015. A product of the project was the site <http://ergolab.wix.com/sicurincampo> that provides a platform for the support of teaching materials for work health and safety training for farmers (training materials in 5 languages).

A previous research from the same Authors (article in press) showed that the perception of risk is related to having attended training courses, but those who report having attended safety courses do not always enact safe behavior.

While we cannot draw conclusions about the behavior of workers after attending the course, the analysis of the questionnaires shows a clear improvement in the perception of risk. Excluding the course restricted to workers of Indian citizenship, for which there was unavailable a statistically significant number of post-course questionnaires, after attending the lessons we observed the following increases of the average values of the scores of the answers:

- Course 1 (only Italians): + 0.32 (from 4.15 to 4.47)
- Course 2 (Italians and Romanians): + 0.33 (from 4.35 to 4.67)
- Course 3 (Italians and Romanians): + 0.27 (from 4.30 to 4.57)

Conclusions

The project "Safe in the Field" was an opportunity to analyze the work environment in the agricultural sector in Lazio Region and the trend of accidents and occupational diseases in the same field.

For the logical sequence adopted and the results obtained we can say that the project can be considered a "reference" replicable in other regions and in other working sectors.

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Influence of training, procedural and organizational measures in the reduction of the risk due to manual handling of loads

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Abstract

The link between the musculo skeletal disorders (especially those affecting the bones, nerves, joints, muscles, tendons and blood vessels) and manual handling of loads, is nowadays worldwide recognized. This risk is present in many production sectors, but in some activities more than others, including agriculture (INAIL), risk indexes are often above the warning thresholds.

The research evaluated 20 agricultural and agro-livestock Lazio's farms, using a methodology proposed by EPM Research Unit (Milano, Italy) in compliance with criteria laid down by Annex XXXIII of the Italian Legislative Decree n. 81/2008 (transposition of several European Directives including 90/269/EEC about manual handling of loads).

This research also studied appropriate ways to make a quantification of the efficiency and effectiveness made by the procedural and organizational redesign proposal, presenting concretely and economically feasible measures, useful in the short term.

Keywords: Niosh, Risk Analysis, Prevention, Safety And Health

Introduction

The link between musculoskeletal diseases and manual handling of loads is nowadays worldwide recognized (Colombini et al, 2003; Nicoletti et al, 2013).

Manual handling of loads consists in transporting or supporting of a load and its shares of lifting, putting down, pushing, pulling, carrying or moving.

The risk of disease due to biomechanical overload, especially of the back, is the result of unfavorable ergonomic conditions (European Directive 90/269/EEC).

The working rhythms imposed on the weather, the conditions of cultivation, the frequent use of unskilled seasonal workers make agriculture one of the most affected sectors by these diseases. These critical factors are complementary for the biomechanical overload.

Methods

The Council Directive 90/269/EEC is transposed in Italy by legislative decree 81/2008.

Annex XXXIII of Leg.dec. 81/08, entitled "Manual handling of loads", gives reference elements to the employer for carrying out a proper risk assessment.

The same Annex requires the employer to consider the personal risk factors of each potentially exposed subject, in order to make a proper risk assessment induced by manual handling of loads, in particular:

- physical unfitness to carry out the task, given the differences of gender and age (maternity, childbirth, youth, old age, etc.);
- clothing, footwear or other personal effects worn by the worker;
- insufficient knowledge, inadequate education and training.

In the observed firms, a manual handling of loads risk assessment model in Excel®

format, provided by EPM - Research Unit (Milano, Italy), has been used for tasks and composite variables.

This model makes possible to carry out a risk assessment providing risk indexes (RI), in accordance with the NIOSH (National Institute for Occupational Safety and Health) method and the technical standards EN 1005-2 and ISO 11228-1.

The model provides the lifting index (in conformity with EN 1005-2 and ISO 11228-1 standards), the value of the risk index obtained by the NIOSH equation (U.S. Department of Health and Human Services, 1994) and an overview of the data entered with the critical issues marked in red.

In addition to the value of lifting indexes, the extract of the spreadsheet associates each class of RI to a color:

- green - risk below the threshold;
- yellow - value close to the limits of attention;
- red - presence of certain risk;
- purple - presence of high risk.

The observations, lead by farm inspectors, were performed during the second half of 2014 on 20 farms and agro zootechnical firms in central Italy.

During the survey, essential data have been detected, as required by the technical standards, as well as additional information in order to operate considerations on efficiency and effectiveness of the preventive measures proposed.

Data have been collected about the presence or absence of training in line with the provisions of article 36 and 37 of the Leg.dec. 81/2008 with the aim of observing how this parameter, considered crucial for the correct postures in the operations of manual handling of loads, influences the efficiency and efficacy of the proposed interventions.

Results

This assessment discovers any critical issue in obtained risk indexes, proposes a suitable design of procedural and organizational measures, aimed at reducing risk, especially trying to assess its efficiency and effectiveness.

The aim of the research is to make a deep survey based in on site interviews and observations, on the working methodologies used by the employees, especially during operations involving the manual handling of loads with magnitude exceeding 3 kg.

The data elaboration highlighted the differences between the risk values obtained by applying the European standard EN 1005-2, the ISO standard 11228-1, and the NIOSH equation. Data were acquired previously and after the application of preventive, organizational and structural measures.

The second part of the research focused on a closer analysis about the influence of the presence or absence of training on the detected risk indexes.

Figure 1 shows the results of a first general analysis. This analysis compares the variation in risk between evaluated and estimated conditions, after the application of the proposed preventive measures. These preventive measures could potentially lead to a reduction of risk ratings: in particular, the values after the application of the suggested measures are 59% (average) less than the values of the initial risk.

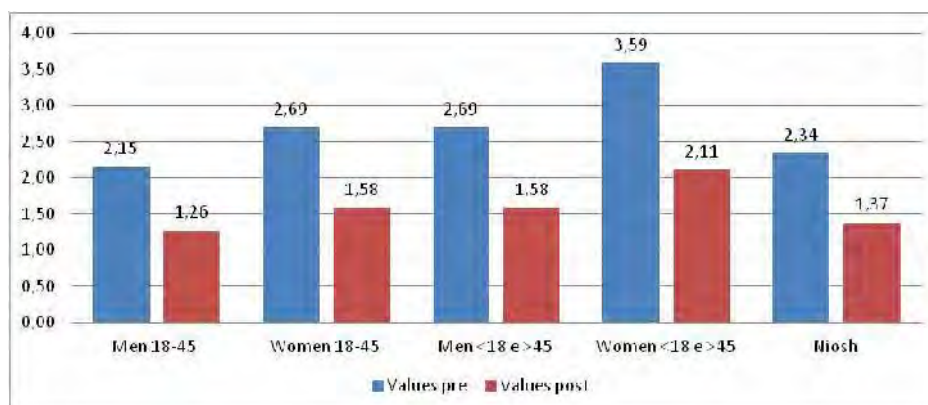


Figure 1. Risk reduction after the application of preventive measures

As it regards the influence of training in the reduction of the risk, as shown in figure 2, we can see that in the farms where workers wasn't subject to training the risk index is increased of 12% (average).



Figure 2. Comparison between risk indexes in farms where training is done and farms where training isn't done

It is important to underline the fact that farms where training was carried out were less than 30% of the total sample (figure 3).

Below there are the results from the second part of the study. The aim is a comparison between the risk indexes in the initial conditions and after the application of technical and procedural measures of prevention in farm.

The proposed measures determine overall reduction of risk ratings. The correct handling procedures can be easily feasible with proper training (posture, lifting of objects with both limbs, lifting of objects in two or more persons, etc.).

In order to evaluate how preventive optimization measures acted on the initial risk, we calculated the ratio between the average risk index after optimization and the average risk index pre optimization.

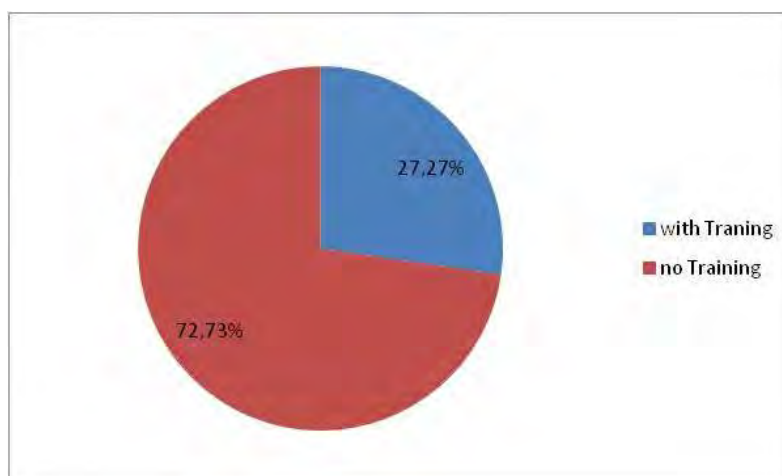


Figure 3. Percentage of farms with and without training

Adopting this method we can obtain the percentage of risk reduction. Example: the initial risk index is quantified 1.98 (average); adopting the preventive measures it is 1.35 (average); in order to estimate the risk reduction, compared to baseline, we apply the following formula: $(1.35/1.98) \times 100 = 68.18\%$.

The thus obtained value indicates that, thanks to the adoption of the suggested interventions for the optimization, the risk is reduced to 68.18%, comparing it to the initially assessed one (efficiency of the measures is calculated as: $100 - 68.18 = 31.82\%$).

The obtained values show how the optimization is able for the risk index reduction.

The difference between the percentage values obtained can be used to estimate how much training could be effective in reducing the risk from manual handling of loads. These values, along with those of efficiency estimated, are shown in table 1 corresponding to the entries: efficiency and effectiveness of optimizations (estimated in percentage).

The table shows the pre and post proceeding values, taking into account the comparison between average values in farms with trained workers and not.

Table 1. Comparison to evaluate performance of training in reducing risk levels by gender and age

	Men18-45	Women 18-45	Men <18 e >45	Women <18 e >45	Niosh
Training first	1,98	2,47	2,47	3,3	2,15
Training post	1,35	1,70	1,70	2,26	1,47
Optimization	68,18%	68,83%	68,83%	68,48%	68,37%
no Training first	2,22	2,77	2,77	3,69	2,41
no Training post	1,23	1,54	1,54	2,05	1,34
Optimization	55,41%	55,60%	55,60%	55,56%	55,60%
estimated efficacy in%	12,78%	13,23%	13,23%	12,93%	12,77%

Conclusions

The preventive measures proposed are aimed to reduce the risk index, so as to protect workers from occupational accidents and diseases. The aim of the research was to estimate, where

possible, the optimization efficiency and effectiveness, both at organizational and procedural level.

We evaluated the effectiveness of the proposed improvements with a mean decrease of risk observed by about 59%. The factor examined, whose absence contributes significantly to increase risk ratings, is the training, that, although present in only 27.3% of the companies observed, show a risk reduction of approximately 12÷13%.

Information and training have a direct effect on reducing the risk as regards the postural attitude (bending of the legs, twisting of the body, etc.) and also for the use of both limbs or lifting of bulky items or too heavy in most people.

The comparison of risk indexes before and after optimizations, among the farms where a suitable training is done and those without training, show that the efficiency of operations in the first farms is approximately 31%, while in farms without training is around 44%.

The lower efficiency measured in companies with training provided, reveals how the training is a preventive measure, with an efficacy estimated around 13%. This efficacy may be far greater with the implementation of a correct training as it regards the manual handling of loads.

Absolutely not negligible and worrying is the absence of training in over 70% of farms, since this is considered an intervention of effective prevention, for this and other types of risks.

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A population-based comparison of injuries among farm and non-farm adults in Alberta, 1999-2010: A retrospective cohort

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Abstract

Agriculture is considered as one of the most hazardous occupations with the 4th highest mortality rates by industry in Canada. The purpose of this study was to examine the rates and risks of (1) all-cause and (2) agricultural injury across adult farm and non-farm populations in Alberta.

We conducted a population-based retrospective cohort study utilizing data from multiple administrative health databases. Crude injury rates were calculated and proportional-hazards regression with a counting process was applied to obtain hazard ratios for injury adjusting age and sex.

We identified a total of 220,911 adults who experienced 947,247 injuries. Rural Non-Farmers experienced the highest death rates at 74/100,000 person-years, followed by the Farm Rural study group at 58, the Urban group at 52.1 person-years and the Farm Urban group at 48.1. All cohorts had higher hazards of all-cause injury when compared to the urban cohort after adjusting for age, and sex (Rural Non-Farm Hazard Ratio (HR)=1.09, 95% CI 1.07-1.10; Farm Urban HR=1.09, 95% CI 1.07-1.10; Farm Rural HR=1.08, 95% CI 1.07-1.09). Farmers experienced 87.5% of all agricultural injuries, with the HR= 4.68 (95% CI 4.39 – 4.99) for Farm Rural and HR= 2.87 (95% CI 2.66 -3.11) for Farm Urban when compared to the Rural Non-Farmers and adjusted for age and sex.

This study identified that injury incidence rates, severity and intent varied among urban, farm and rural cohorts. These observations suggest that intervention initiatives, with specific population and mechanism targets, are needed to tackle the challenges of injury prevention in different rural populations.

Keywords: Agriculture, Injury, Health Data, Death

Introduction

Agricultural work in the United States and Canada continues to be one of the most dangerous vocations (Voaklander, Hartling, Pickett, Dimich-Ward, & Brison 1999; Brison, & Pickett 1995; Pickett, Hartling, Brison, & Guernsey, 1999; Frank, McKnight, Kirkhorn, & Gunderson, 2004; McCurdy, & Carroll, 2000; Statistics, Bureau of Labor, 2006). In 2005, agriculture had the highest occupational fatality rate in the United States (US) with 32.5 fatalities per 100,000 workers; this is a 23% increase from 2004 (Statistics, Bureau of Labor 2006), while in Canada the fatality rate is somewhat lower at about 20.3 fatalities per 100,000 workers, ranking it historically as Canada's fourth most dangerous occupation (Pickett, 1999). Furthermore, farmers residing on farms are inherently exposed to farm machinery and the associated hazardous risks regardless of whether or not they are participating in farm work (Marlenga, Pickett, & Berg, 2001; Voaklander, Day, Hagel, Dosman J & Pickett W 2012).

It is also well established that rural living is a risk factor for injury. Rural factors that persons at higher risk include: greater distances traveled and higher driving speeds (Mitchell-Taverner, & Zipparo, 2011), more frequent alcohol use (Muelleman, & Mueller, 1996), lower

occupant restraint usage (Belton, 2005) as well as lower socio-economic status (Gilbride, Wild, Wilson, Svenson, & Spady, 2006; Singh, 2002).

However, what is not known is the risk for injury across farmers, rural non-farmers and urban dwellers. Using data linkage of government registries we had a unique opportunity to compare the injury experience of both farm and rural non-farm populations to urban dwellers in the province of Alberta, Canada.

Methods

Study Design

We conducted a population-based retrospective cohort study with a closed population to examine rates, risks and patterns of all-cause and agricultural injury in the adult farm and non-farm populations in Alberta during the period starting January 1, 1999 to December 31, 2010.

Data Sources: Injury data were obtained from four administrative health databases: The Alberta Vital Statistics File containing mortality data; the Hospital Discharge Abstract Database (DAD) provided data on hospital admissions; the Ambulatory Care Classification System (ACCS) containing emergency department (ED) visits; and the Physician Claim File that contained data on physician encounters. The Physician Claim File consisted of services performed in a physician office, in the hospital, in the ED, or other diagnostic/therapeutic settings. Demographic information on subjects including age, sex, first three digits of the postal code, migration, health zone, and socio-economic status was obtained from the Alberta Health Care Insurance Plan Registry file. Records for each individual were linked across these data sources, using a scrambled personal health number. The resulting database contained multiple injury records at different levels of care (e.g. hospitalization, emergency department visits) for each individual.

Study participants

The study participants were categorized into farm, urban and rural groups. Farm-based individuals were identified using the Farm Fuel Tax Rebate system that captured addresses from all commercial farm operations in Alberta. Address data from this system were probabilistically linked to Alberta Health Care Insurance Plan registry to identify farm residents of all ages. Urban non-farmers and rural non-farmers were randomly selected via postal codes to create size equivalent comparison groups.

As there were farmers with non-rural postal codes, the farm group was further subdivided into Farm-Rural and Farm-Urban groups to examine differences in rates and hazards for injury between the two groups.

The study included subjects who were 18 years of age or older and lived in Alberta in the fiscal year 1998/99. During the study period, subjects were considered lost to follow up upon the fulfillment of the following conditions: the first move-out from Alberta; the first move-out from rural to urban areas or vice versa; and the first discontinuance of registration in the Alberta Health Insurance plan (99% coverage).

Injury identification

Injuries were identified using the following International Classification of Disease (ICD) 9 and 10 codes for external causes of injury found in any of the diagnosis fields of each medical record. Any injuries that occurred in an urban setting, except for those occurring in the Farm-Urban group, were excluded from the analysis of agricultural injuries. As vital statistics records contained only one diagnosis field for the cause of death, it was not possible to identify fatal agricultural injuries by place of occurrence, thus restricting the analyses of fatal agricultural injury to machinery, transport and poison related events only.

Injury episode

As stated above the created data set contained multiple injury records per individual post database linkage. As treatment of a single injury incident may require more than one healthcare visit, some of the records represented healthcare visits due the same injury. In order to calculate incidence rates, distinct injury episodes that omit follow up visits for the same injury needed to be identified (Lestina, Miller, & Smith, 1998). To create such an episode, all records were sorted by personal health number, date of service and level of care and any follow up visits for the same injury were identified using carefully selected criteria as outlined in Table 1 (Kim, 2013). The identified follow up visits were subsequently removed leaving a single record at the highest level of care to represent a distinct injury episode. As the severity of an injury correlates with the type of healthcare service needed by the individual, the level of care of each episode was used as a proxy to the severity of the injury. In order to exclude visits that were actual follow ups of injuries which occurred before the study began (January 1, 1999), records from three years prior to the study were used in the episode creation process.

Table 1. Criteria used to differentiate between follow up and new injury records.

Criterion	Description
1	The injury record had ICD codes for sequelae or late effect of injury
2	The injury record appeared on the same day
3	The injury occurred within 7 days in the same category of body region or the nature of injury
4	The injury occurred within 180 days in the same category of both body region and nature of injury
5	The injury occurred within 180 days with the exactly same diagnostic codes in all ten ICD diagnostic fields compared with the previous injury record
6	The injury record had ICD codes for sequelae or late effect of injury
7	The injury record appeared on the same day

Statistical analysis

Descriptive statistics including frequencies, percentages and means were used to summarize participants' demographics. One-way ANOVA and Chi-square test were used to determine significant differences in the demographic variables between study groups.

Crude incidence rates of all-cause and mechanism-specific injuries were calculated using injury episodes as the numerator. Crude relative risks of cause-specific injury and their 95% confidence intervals were calculated for each cohort using the urban cohort as the reference group. For the analysis of agricultural injuries, the rural farm group was used as the reference group for the same.

Several distinct injury episodes were experienced by some participants. In order to account for the recurrent time to injury events, proportional-hazards regression with a counting process was applied to obtain hazard ratios (HR) of injury while adjusting for confounders such as age and sex. Robust standard errors were used to adjust for correlation between the multiple outcomes per individual. Data management and statistical analysis was conducted using SPSS Version 22.0 and SAS Version 9.4.

Results

Sample demographics

There were 143,431 farmers of all ages identified through data linkage with equivalent groups of rural non-farmers and urban dwellers generated through random sampling. After restricting the study population to those 18 years and older and removing First Nations persons (n=11,933) there were 102,758 urban, 88,623 rural non-farm and 100,822 farmers available for analysis. The average age among the study groups varied between 43.5 to 46.9 years (Table 2.). Majority of farmers and Rural Non- farmers were located in the Central (34.8% and 31.3% respectively) and Northern regions of Alberta (28.4% and 29.2%). A portion of farmers however resided in urban areas (27.0%) and was located mainly in the Central and Edmonton regions (32.1% and 22.0% respectively).

During the study the Rural Non-Farmers had the highest loss to follow up among the groups (57.3%), which was mainly due to movement to an urban location.

All-Cause Injury

Between January 1, 1999 and December 31, 2010, we identified a total of 220,911 adults who experienced 947,247 injuries. These were comprised of 617,173 (65.2%) Physician's office visits, 300,729 (31.7%) Emergency Department visits, 27,783 (2.9%) Hospitalizations and 1,562 (0.2%) Deaths.

The highest crude incidence rates of all-cause injury were among the Rural Non-Farmers except for physician office visits, where the Farm Urban study group had the highest rate followed by Urban and Rural Farm groups (Table 3.).

Hazard rate analysis showed that the rates of injury were higher in all study groups in comparison to the Urban group, when adjusting for sex and age (Table 4.). The hazard rates increased with increasing level of care for all groups indicating that farmers and rural inhabitants were more likely to experience a severe injury than the Urban group.

Males had a higher hazard of all-cause injury than females across all levels of care with the highest hazard rate for fatal injuries (HR 2.35 95% CI 2.11 – 2.62).

By intent the highest incidence rates of all-cause injuries were observed with unintentionally inflicted injuries for all groups (Table 5.). The main mechanisms included falls, struck, transport, overexertion, and cut (Table 6.). Among transport injuries the main mechanisms were motor vehicle traffic accidents for the non-farm groups and other land transport (including animal or animal drawn vehicle and special off terrain vehicles) for the farm groups. Both the farm groups and rural non-farmers were at a higher risk of unintentional injuries when compared to the urban cohort and at a lower risk of self-inflicted and purposefully (violently) inflicted injuries.

Agricultural Injury

Agricultural injuries represented 1.21% of all-cause injury. There was a total of 11,439 injury episodes identified in the study period which were composed of 10,066 (88.0%) Emergency Department visits, 1,332 (11.6%) Hospitalizations and 41 (0.4%) Deaths. The highest rates of agricultural injury were experienced by the Farm Rural group followed by the Farm Urban cohort across all levels of care (Table 7.).

Comparing the hazard rates of agricultural injury at different levels of care, both farm groups experienced significantly higher hazards of injury in comparison to the Rural Non-farm group when adjusting for age and sex (Table 8). These were particularly higher for injuries requiring hospitalizations suggesting that farmers were at a higher hazard of more severe injuries. The hazard ratios for fatal injuries appeared in contrast to the above

observations and were lower than for hospitalizations, however underestimated values for fatal agricultural injuries were expected due to the limited vital statistics coding available.

Males overall experienced higher hazard rates of agricultural injury than females across all groups with a hazard rate ratio at 4.03 (95%CI 3.82 – 4.25). This ratio increased with increasing severity of injury.

A slight decrease in the hazard rate of overall agricultural injury was observed with increasing age; at 0.5% with every year increase, while adjusting for sex and group allocation.

The mechanisms of agricultural injuries with the highest crude incidence rates were environmental factors¹ (mainly animals) and machinery across all groups (Table 9). The highest incidence rates for fatal agricultural injuries as presented by the available data were for machinery and transport related injuries (26 and 14 out of 41 deaths respectively) and were mainly among farmers (22 and 13 respectively).

Conclusions

This study enabled a detailed assessment of injuries within various populations by amalgamating data from several healthcare databases.

Injury rates and types were compared between an urban population and different rural and farming populations. The urban group was found to be at a lower hazard of overall injury, as well as having less severe injuries, this being more prominent when compared to the farmers. Multiple studies have previously addressed the difference in injury rates between urban and rural settings, concluding urban settings to be safer (Young, Wasiak, Webster, & Shayne, 2008; Myers et al., 2013; Boland, Staines, Fitzpatrick, & Scallan, 2005). Very often however, this was limited to unintentional injuries. When the intent of injury was considered, our study showed the urban group to be at higher risk of self-inflicted and violently inflicted injury than any other group in the study.

Unintentional injuries being the leading cause of injury among the rural and farm groups indicated an exposure to hazards distinctive to the rural and farm environments. Rural communities have been described to be exposed to more challenging environments; for example transport over longer distances and with more hazards on the roads than their urban counterparts (Canadian Institute for Health Information, 2006; Young et al., 2008). Farming itself is considered as one of the most hazardous occupations by industry and is unique in that farmers both work and live in their occupational environments (Sharpe, & Hardt, 2006; Canadian Agricultural Injury Reporting (CAIR), 2012). These factors largely contribute to injury exposure.

The top mechanisms of unintentional all-cause injury were falls and transport. Breaking these down further showed farmers to have experienced more animal related transport injuries than the urban and rural non-farm groups. This was consistent with agricultural environments and further heightened the concept of injury diversity among the study groups.

The analysis of agricultural injuries showed that the rural non-farmers were exposed to agricultural injuries although their rates and severity were significantly lower than for farmers. This suggests that a proportion of the rural population participated in on-farm activities although farmers experienced higher hazards of injury as well as injuries with higher severity.

The study was also able to include in the analysis a group of urban farmers, that is, individuals living in urban areas that were also farm owners. Similarly to the rural farmers, this group had higher hazards of all-cause and agricultural injury when compared to the

¹ Environmental Factors: Natural environment including living and non- living things including mammals, arthropods, their bites and stings, heat, cold etc.

reference groups, but were at a slightly lower hazard of injury than their rural counterparts. Their mechanisms of injury were also similar to the rural farmers. This indicated that owning a farm regardless of registered residence, placed individuals at a higher hazard of injury than other urban or rural residents.

The top mechanisms of agricultural injury involved the exposure to animals and machinery. Both are identified as a major occupational risk for farmers (Pickett, Brison, Niezgoda, & Chipman, 1995; CAIR, 2012; Casey et al., 2014). Furthermore this also correlates with the major agricultural sectors of Alberta, namely livestock and crop production.

Overall agricultural injuries were experienced more by male than female individuals which correlates with the available data on gender specific farm ownership and on farm activity in Canada. There are more single male farm owners than female farm owners and females tend to spend less amount of time working on farms than males (Statistics Canada, 2001).

The heightened severity of injury experienced by farmers in comparison to the other groups was prominent in both the all-cause and agricultural injuries. This correlates with the aforementioned uniqueness of the farm environment and the dangers of the occupation. Farmers work more closely with animals and operating machinery, they are known to work beyond the anticipated retirement age and factors such as seasonality and sleep deprivation have also been shown to contribute to farmers' injuries (Voaklander, Day, Dosman, Hagel, & Pickett, 2012; Heaton, Azuero, Phillips, Pickens, & Reed, 2012). Limited access to health care due to the remote location and longer emergency response times have also been identified as contributors to severity of injuries for overall rural populations (Rogers et al., 1997; Grossman et al., 2010; Simons et al., 2008; Myers et al., 2013). It is important to recognize these specific challenges especially in the development of injury prevention initiatives as well as organization of emergency response in rural areas.

Limitation of the study were linked to the inherent limitations of using administrative databases for research. Administrative databases provide consistent and more complete data including standardized entry, inclusion of individuals that may have not been captured in other study designs and/or surveys as well as limiting losses to follow-up for reasons other than movement from designated study groups. In spite of the wealth of information provided, administrative databases have not been designed for epidemiological purposes, thus limiting the control of the type of data collected. The vital statistics database presented such a case in this study, where the absence of information on death location reduced the ability to identify all agricultural fatal injuries. In spite of this limitation the obtained rates of the fatal injuries were able to contribute to the understanding of rate distributions as well as injury severity.

Erroneous data entry presented another limiting factor to the study but as it would create non-differential misclassification of injuries within the groups studied, it would not affect the study measures.

The study presented an approach that allowed for a comprehensive analysis of injury in different populations in Alberta. Different rates, hazards, patterns and mechanisms of injury were clearly identified among the different groups. More attention needs to be paid to these population specific vulnerabilities so that injury prevention strategies as well as support services development can be tailored towards unique populations and mechanism targets.

Table 2. Subject Demographics

Description	Urban N= 102,758	Rural non-Farm N=88,623	Farm-Urban N=27,278	Farm-Rural N=73,544
Gender (male)**	49.3%	49.9%	54.5%	54.3%
Age (years, mean±SD)**	43.5±16.8	45±17.8	46.9±16.0	45.8±16.0
Health Services Zones				
Calgary	41.0%	19.0%	12.1%	10.8%
Central	8.1%	31.3%	32.1%	35.8%
Edmonton	38.1%	7.3%	22.0%	4.4%
North	6.3%	29.2%	18.7%	32.0%
South	6.5%	13.2%	15.2%	17.1%
Lost to Follow up**	31.0%	57.3%	21.1%	27.6%
Person-years followed				
Female	515,647	324,984	132,738	341,765
Male	482,540	313,199	156,180	401,729
Total	998,187	638,184	288,918	743,494

*p-value < 0.001 ** Any subsidy received for health care insurance premium

Table 3. Crude incidence rate of all-cause injury by level of care

Level of Care	Urban			Rural non-Farm			Farm_Urban			Farm_Rural		
Crude incidence rate (injuries/100,000 person years) (95% CI)												
Physician claim	23786.5	(23783.9,	23789.2)	22315.8	(22312.6,	22319.1)	24022.1	(24017.1,	24027.1)	22585.1	(22582.1,	22588.2)
ED visits	9053.1	(9051.3,	9054.9)	13106.6	(13103.9,	13109.2)	11454.1	(11450.4,	11457.8)	12592.6	(12590.2,	12595.0)
Hospitalizations	869.6	(869.0,	870.2)	1313.4	(1312.5,	1314.3)	947.7	(946.6,	948.8)	1073.7	(1073.0,	1074.5)
Deaths	52.1	(52.0,	52.2)	74.0	(73.8,	74.2)	48.1	(47.9,	48.4)	58.0	(57.8,	58.1)

Table 4. Hazard ratios of all-cause injuries

Level of Care	Rural Non-Farm			Farm_Urban			Farm_Rural		
	Hazard Ratio (95% Confidence Interval), Reference group: Urban								
All Levels of Care	1.09	(1.07,	1.10)	1.09	(1.07,	1.10)	1.08	(1.07,	1.09)
Physician Visits	1.02	(1.01,	1.04)	1.08	(1.06,	1.10)	1.08	(1.06,	1.10)
Emergency Visits	1.24	(1.22,	1.26)	1.15	(1.13,	1.17)	1.17	(1.16,	1.19)
Hospitalizations	1.30	(1.26,	1.35)	1.13	(1.08,	1.19)	1.25	(1.20,	1.29)
Deaths	1.34	(1.18,	1.52)	0.995	(0.83,	1.20)	1.18	(1.04,	1.34)

Table 5. Crude rates and rate ratios of all-cause injuries by the intent of injury

Intent of Injury	Level of Care	Urban	Rural non-F	Farm-U	Farm-R	Rural non-Farm	Farm-Urban	Farm-Rural					
		Incident Rate (Injuries per 100,000 person-years)				Rate Ratio (95% CI), Reference Group: Urban							
Unintentional	ED visits	7052	11669	9849	11214	1.65	(1.64, 1.67)	1.4	(1.38, 1.42)	1.59	(1.57, 1.61)		
	Hospitalizations	756	1163	877	992	1.54	(1.49, 1.59)	1.16	(1.11, 1.21)	1.31	(1.27, 1.36)		
	Deaths	27	51	35	42	1.92	(1.63, 2.26)	1.33	(1.06, 1.67)	1.58	(1.34, 1.86)		
Self-harm/ Suicide	ED visits	92	36	22	10	0.39	(.34, .45)	0.24	(.19, .31)	0.1	(8.24, .13)		
	Hospitalizations	54	48	20	22	0.89	(.77, 1.02)	0.38	(.29, .49)	0.4	(.34, .48)		
	Deaths	16	17	11	13	1.05	(.82, 1.34)	0.7	(.48, 1.02)	0.81	(.63, 1.04)		
Violence/ Purposely inflicted	ED visits	226	194	96	79	0.86	(.80, .92)	0.42	(.37, .48)	0.35	(.32, .38)		
	Hospitalizations	23	23	9	9	0.99	(.80, 1.22)	0.39	(.26, .58)	0.39	(.30, .51)		
	Deaths	1	1	0	1	1.01	(.44, 2.32)	0.25	(3.25, 1.88)	0.86	(.37, 1.99)		
Undetermined	ED visits	28	43	26	32	1.53	(1.30, 1.81)	0.92	(.71, 1.18)	1.15	(.97, 1.37)		
	Hospitalizations	9	21	7	12	2.25	(1.73, 2.94)	0.74	(.46, 1.20)	1.24	(.93, 1.66)		
	Deaths	8	5	1	2	0.59	(.39, .89)	0.17	(6.18, .46)	0.23	(.13, .40)		

F - Farm; U –Urban; R-Rural; ED - Emergency Department; 95% CI - 95% Confidence Interval

Table 6. Mechanisms of unintentional all-cause injury

Mechanism	Urban	Rural non-F	Farm-U	Farm-R	Rural non-Farm			Farm-Urban			Farm-Rural		
	Crude rate (injuries per 100,000 person-years)				Crude Rate Ratio (95% CI), Reference Urban								
Fall	2283	3270	2293	2366	1.43	(1.41,	1.46)	1.00	(0.98,	1.03)	1.04	(1.02,	1.06)
Struck	992	1392	1129	1240	1.40	(1.36,	1.44)	1.14	(1.09,	1.18)	1.25	(1.22,	1.29)
Unspecified	934	1757	1250	1574	1.88	(1.83,	1.93)	1.34	(1.29,	1.39)	1.69	(1.64,	1.73)
Transport	929	1314	1158	1232	1.42	(1.37,	1.46)	1.25	(1.20,	1.30)	1.33	(1.29,	1.37)
Overexertion	858	1125	840	879	1.31	(1.27,	1.35)	0.98	(0.94,	1.02)	1.02	(0.99,	1.06)
Cut	744	1390	1156	1316	1.87	(1.81,	1.93)	1.55	(1.49,	1.62)	1.77	(1.72,	1.82)

Table 7. Crude incidence rate of agricultural injury

Level of Care	Rural Non-Farm			Farm-U			Farm-R		
Crude incidence rate (injuries/100,000 person years) (95% CI)									
ED visits	201.5	(201.2,	201.9)	575.9	(575.1,	576.8)	957.1	(956.4,	957.8)
Hospitalizations	21.0	(20.9,	21.1)	84.5	(84.1,	84.8)	128.3	(128.1,	128.6)
Deaths	0.9	(0.9,	1.0)	3.1	(3.1,	3.2)	3.5	(3.5,	3.5)
ED - Emergency Department									

Table 8. Hazard ratios for agricultural injuries

Level of Care	Farm_Urban			Farm_Rural		
	Hazard Ratio (95% Confidence Interval), Reference group: Non-Farm Rural					
All levels of care	2.87	2.66	3.11	4.68	4.39	4.99
Emergency Visits	2.80	2.57	3.04	4.62	4.32	4.94
Hospitalizations	3.96	3.97	5.34	6.39	5.28	7.74
Deaths	3.19	1.14	9.00	3.93	1.62	9.56

Table 9. The leading causes of agricultural injuries

Mechanism	Rural non-F	Farm-U	Farm-R	Farm-Urban			Farm-Rural		
	Crude rate (injuries per 100,000 person-years)			Crude Rate Ratio (95% CI), Reference Urban					
Environmental Factors	50	163	253	3.23	(2.80,	3.72)	5.02	(4.46,	5.65)
Machinery	41	159	228	3.86	(3.32,	4.49)	5.56	(4.88,	6.33)
Other CI	30	76	149	2.56	(2.11,	3.11)	5.00	(4.28,	5.83)
Struck	22	73	111	3.28	(2.65,	4.06)	4.99	(4.18,	5.97)
Fall	22	68	102	3.14	(2.52,	3.90)	4.71	(3.93,	5.65)
Cut	20	46	100	2.35	(1.84,	3.00)	5.10	(4.22,	6.17)
Overexertion	14	31	54	2.18	(1.64,	2.92)	3.73	(2.98,	4.68)
Transport	15	31	45	2.11	(1.58,	2.82)	3.08	(2.45,	3.87)

F - Farm; U –Urban; R-Rural; 95% CI - 95% Confidence Interval

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Assistive Technology Database for Farmers and Agricultural Workers with Physical Disabilities

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Abstract

Purdue University manages the largest known database of assistive technology appropriate for safely enhancing the independence and productivity of farmers and agricultural workers with physical disabilities. The poster will explain the organization structure of the database (www.agrability.org), the contents and how it is used internationally by rehabilitation professionals working with farmers. Data on visits to the site and the most commonly used components will be presented.

Key components of the website relate to both commercially available devices and locally fabricated devices that have been designed to increase the independence of those engaged in production agriculture. The database currently includes over 1,100 items. Additional resources include technical articles on a wide range of barriers faced by persons with disabilities.

Users of the site represent over 20 countries and include primarily rehabilitation professionals and farmers with disabilities. Approximately 5,000 unique visits are made to the site each month.

Injuries for female workers in agriculture – An initial study on causes and preventive measures

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Abstract

The aim of this paper was to contribute to the future prevention of women's occupational injuries in agriculture via identifying the main causes and circumstances related to these injuries.

The study included analyses of existing data of occupational injuries during a five year period (2009-2013) suffered by women working in agriculture in Sweden. The injury data consisted of compensated work injury claims from the AFA Insurance and work injuries reported to the Swedish Work Environment Authority. Descriptions of the specific events of about 600 injury claims and reports were studied thoroughly in order to gain a deeper understanding of the causes and circumstances. The data regarding, for instance, the source of injury, age, time of year, type of production, injury characteristics and other factors, were analysed. Based on the statistical output, the causes and possible preventive measures were discussed with a reference group consisting of people with extensive practical experience in the area of agriculture work environment.

Preliminary findings indicated that the majority of injuries were animal-related (~55 % of the injuries), with cattle as the most commonly involved animal followed by horses. Cases associated with sorting/moving cattle, leading horse and milking tasks represented high proportions of the injuries. Working with livestock were subjects to the injury in 64 % of the cases, and younger women (<25 years) seemed to be overrepresented in the statistics. The injuries occurred more frequently in the months of September and December.

The further analysis of the injuries should be carried out as a case study together with the suffered persons in the field to gain more detailed information of the underlying causes and suggest more specific measures. The focused areas of preventive measures were also discussed.

Keywords: Prevention, Risk, Work-Related Injury, Statistics, Animal.

Introduction

According to European Agency for Safety and Health at Work (EU-OSHA, 2010), the number of jobs in agriculture has declined for both women and men. There are more women than men work involuntarily in the agriculture sector in fixed-term jobs. Agriculture is one of the most accident-prone industries. In recent years, the most serious work-related accidents and fatalities has been reduced in Sweden (SäkertBonförnuft, 2013). However, the latest statistics reveals that women are exposed to a higher risk of work-related injury as compared to the men who work in the agriculture (AFA, 2013; Swedish Work Environment Authority, 2013; EU-OSHA, 2014). The AFA Insurance (AFA, 2013) has shown that the risk rate (number of serious accidents at work per 1,000 persons employed) in agriculture was 7.1 for women and 4.9 for men in 2011 (Table 1).

Table 1. Approved serious accidents at work for men and women in agriculture (agricultural, forestry and gardening) and the proportion of accidents that led to medical disability in 2011, as well as risk rate during years 2009 to 2011 (AFA, 2013).

	No of claims 2011	Share with medical disability,%	Risk rate *		
			2009	2010	2011
Men	168	71.4	4.5	5.3	4.9
Women	78	66.7	6.4	5.2	7.1

* Number of serious occupational accidents per 1 000.

Statistics from the Swedish work environment authority (ISA, 2014) showed the similar results when the number of notified occupational accidents per 1 000 workers in agriculture for women (6) was twice higher than that for men (3) during years 2011-2013 (Table 2). In addition, women's relative injury rate has remained constant during years 2008 to 2013, while men's gradually dropped. This means that the risk of the serious occupational accidents in general for women working in agriculture seems to be higher than that for men.

Table 2. Number of accidents per 1 000 working people of men and women in the field of agriculture and hunting during years 2008 to 2013 (ISA, 2014).

	2008	2009	2010	2011	2012	2013	No. of claims 2013
Men	5	4	4	3	4	3	135
Women	6	6	6	6	6	6	89

The most common work-related accidents in agriculture in general are accidents with animals and machines as well as falls. With the knowledge available today, however, we cannot say about the misfortunes suffered by women is due to a higher exposure to risk or if there are other factors that have an impact. Therefore, the present study is implemented to see how the incidences of work-related injuries widespread.

The overall objective of this study is to contribute to the future prevention of women's occupational injuries in agriculture *via* identifying the main causes and circumstances related to these injuries. The results can be used as a basis for the suggestion on possible prevention strategies.

Materials and methods

The study included analyses of existing data of occupational injuries during a five year period (2009-2013) suffered by women working in Swedish agriculture. The injury data consisted of compensated work injury claims from AFA Insurance and work injuries reported to the Swedish Work Environment Authority. Descriptions of the specific events of about 600 injury claims and reports in total were studied thoroughly in order to gain a deeper understanding of the causes and circumstances.

The data regarding the source of injury, age, time of year, type of production, injury characteristics and contributing factors were analysed. Based on the statistical output, the causes and possible preventive measures were discussed with a reference group consisting of people with extensive practical experience in the area of agriculture work environment.

Results

The studied statistical data showed that there were 3 deaths, i.e., one took place at loading of calves, one happened in the feeding of horses and one occurred when working with suspended forage wagon during the five-year period (2009-2013). A total of 30 % of the 592 accidents led to a sick leave for more than 14 days. By AFAs, 355 cases were the 45% that was serious injury that led to sick leave for more than 30 days and/or medical disability, and 27% which led to medical disability.

Of investigated accidents that resulted in medical disability it was 57% who were directly or indirectly related to work with animals, that is, occurred during milking, cleaning/strewing, feeding, removal and loading of animals and riding/driving. Moreover, it was widely circulated on the operations.

Number of notified occupational accidents per year

Figure 1 shows the number of notified occupational accidents per year suffered by women in agriculture for the period 2009-2013. The number of notified cases has grown steadily over this period.

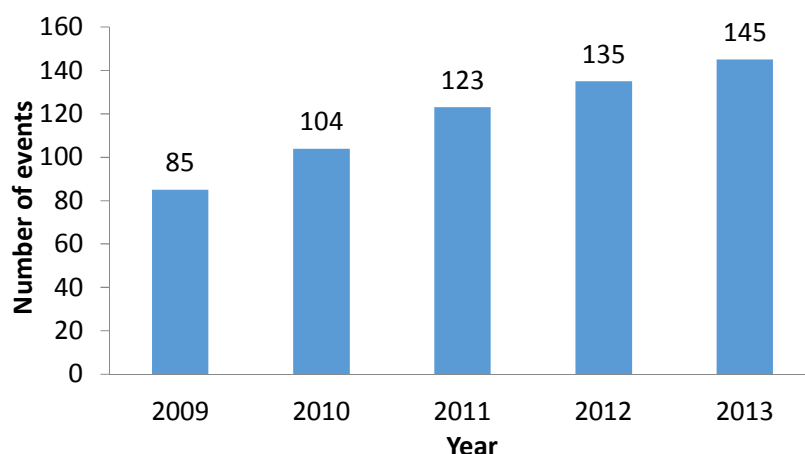


Figure 1.Number of notified occupational accidents in agriculture during the years 2009-2013 (merger of AFAs and AVs data, a total of 592 cases).

Time over the year

Figure 2 shows how the numbers of notified accidents suffered by women are distributed over the year. Most accidents occurred in September, followed by the December and March. The least number of accidents occurred in May and August.

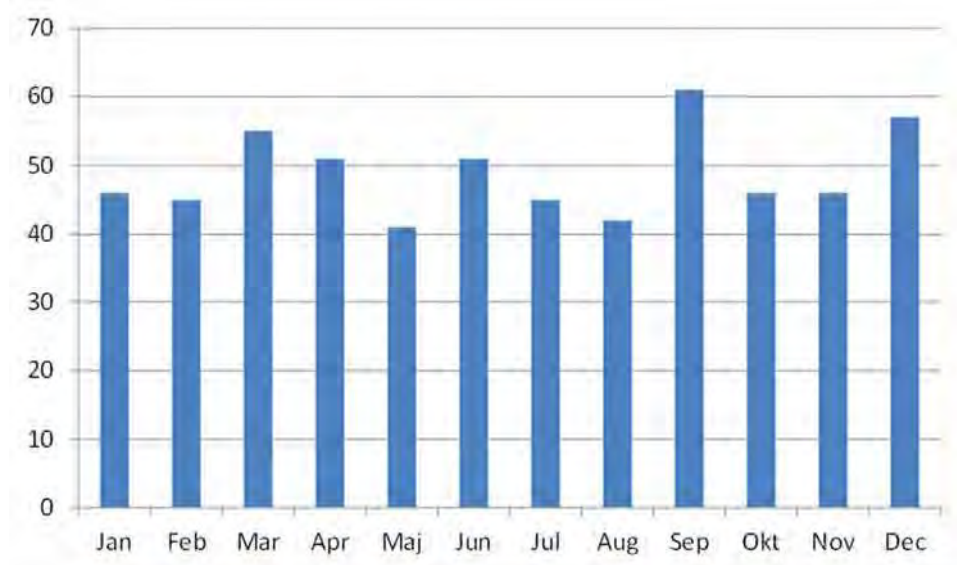


Figure 2. Distribution of number of notified occupational accidents per month during the years 2009-2013 (587 of 592 cases, 6 were missing date of injury).

Age distribution

Figure 3 shows the accidents distributed in different age groups. In 27% of accidents (162 of 592) were the injured women younger than 25 years. Only 15% of those injured was 55 years of age or older. The other injured were distributed relatively evenly between the age groups 25-34 years, 35-44 years and 45-54 years. The average age for all damaged at the time of the accident was 38 years. To be able to parse the result, this aging is related to the age distribution of the overall number of women working in agriculture.

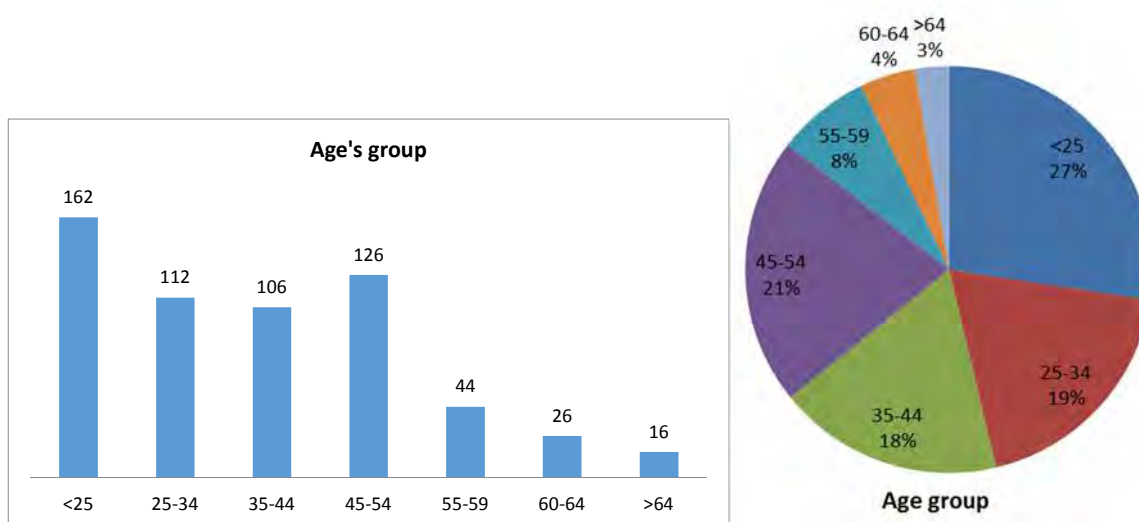


Figure 3. Number and proportion (%) of notified occupational accidents in different age groups (total for the years 2009-2013).

Furthermore, it has specifically been studied on how the distribution of accidents looks within occupational groups for the age group < 25 years, because this particular age group had the highest proportion of accidents by all professional groups.

Damage caused by animals constituted the majority of accidents in women < 25 years. An analysis of the external factor that caused damage of work showed that cattle were the

external factor of 38% of the accidents and horses were that of 22% of the accidents. The operations where most accidents took place were in milking, followed by other cattle handling, remove/sorting of cattle and lead/moving horse.

About 14% of the 162 accidents led to a sick leave beyond 14 days and a total of 18 injuries reported as having led to any degree of medical disability (that is, permanent physical disabilities).

Operations

The most common operations performed in connection with that accident happened was milking, moving/sorting of cattle and other handling of cattle (Figure 4). These three operations accounted together for 28% of the total number of accidents. A significant proportion of accidents (15%) were also associated with horse handling of various kinds, i.e., leading/moving horse, riding/driving horse and other horse care. A more detailed description of these operations and the underlying causes are presented in “Common accidents at specific operations” section. Animals of other animals include animal beaten pig, sheep, poultry and a case with llama. The accidents took place mainly in connection with insemination, vaccinations and other treatments as well as killing.

In the figure 4, the category of “Animal care” includes elements in different ways that means the management of the animals, while feeding and cleaning/strewing presented in separate categories. Accidents related to feeding and cleaning/strewing accounted for 12% of cases. Common accidents in the feeding were falls (slipping/tripping/ wrong ramp) and kind of animals (be run/kicked/on hit). Even during cleaning, the accidental falls and blows from animals occurred frequently. Also, there exists a chemical damage of disinfectants and pinching during cleaning of the conveyor belt.

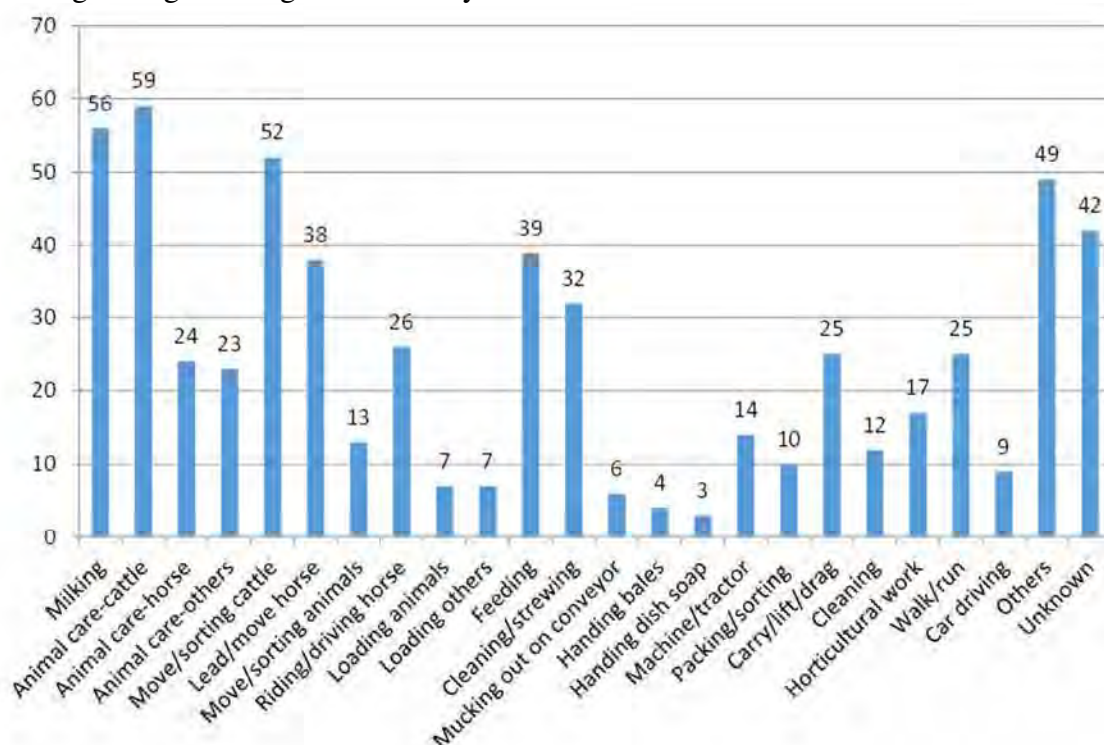


Figure 4. Number of notified occupational accidents that occurred in the context of the various items or stages of work (total 592 accidents).

Moreover, the most injury prone operations, and how and why accidents happen has been analysed in the following *common accidents at specific operations*.

Caring for cattle

There were 59 accidents, which occurred at other maintenance of cattle (other than milking and relocation of animals). The largest share (17%) occurred in the treatment, such as blood sampling, vaccination and treating calving paralysis. Table 3 shows all the operations in other cattle management.

The cows were the external injury factor in 63% of the injuries in the maintenance of the bovine species (including 7% was cow with calf), followed by calf for 10% of the damage, heifer in 8% of the damage and the bull in 5%. Other injuries had an exterior damage factor, i.e., floor/surface (7%), grind/tube (3%) and cutting machine/knife (3%). Common injuries were kicked, hit, pinched, walked and jostled.

Table 3. Operations are included in the category of “Animal care-cattle” (Figure 4). Number and percentage (%) of accidents during years 2009-2013.

Operations	No of claims (share in%)	Case in point
Treatment	10 (17)	-Be wielding to head just when the person would stick in the syringe, stick in hand -Help vet, cow became afraid, walked
Pregnancy-study	7 (12)	-In pregnancy investigating a cow, another cow pushed himself between me and the cow with the result that my arm pinned firmly
On/off with the Halter necklace	6 (10)	-Tie up and put the Halter on cow. Kind of cow face
Handling cow	6 (10)	-Tried to stop cow, hand caught between pallet and cow -Would help a cow stuck in the fastening, cone got up and became stamped on the person’s foot
Calf management	5 (8)	-Help the calf to drink (breast-feed), jostled by calf
Insemination	5 (8)	-Pinched when the animal moved out
Supervision	5 (8)	-Controlled new born calf and newly calved cow. The cow butted me
Calving	3 (5)	-Back problem was triggered during an ongoing helps process with chain at calving
Clipping	3 (5)	-I coin with cut machine, got cut up in mouth
-Mouth machine manufacturing	3 (5)	-Cow kicks the arm at the fixation of bone
Miscellaneous	6 (10)	-Heifer had stuck under a gate, fired at frightening -Close a gate, a bull kicked at the gate
Total	59 (100)	

Of these 59 occupational accidents, the body part that was damaged in the accidents that occurred during care of cattle. The most common case was bone including knee (12%), back/spine/vertebrae (10%), arm, including elbow (10%) and hand (10%). In these injuries, were 21 (i.e., 36%) that have been leading to a sick leave longer than 14 days, and 8% of these cases led to some degree of medical disability.

Moving/sorting cattle

52 accidents occurred at work to move or sort the cattle. The animal category cow was the external injury factor in 29% of the damage (of which 4% was cow with calf), followed by Heifer in 27% of the damage, bull in 8%, veal in 4% and unknown cattle in 4% of cases. Other injuries had exterior damage factor on floor/surface (19%). Those cases of accident resulted in the damage were slipped, stumbled or stepped wrong, and grind/tube (10%). Typical cases of accidents when moving/sorting of cattle were:

- An animal went to fit, jammed against the gate
- Running to catch up with shoes, slipping on the grass, falls
- Downloaded cows in loose operation. Among the cows was an untethered bull. While working the bull attacked from behind, butted over and pressed the person along the floor towards the Interior
- Heifer's turned, ran at boom who met someone in the chest that fell

Common injuries were kicked, punched between the animals and the wall/decor as well as attacked. The injured body parts that were most abundant at the accidents that occurred during removal/grading of cattle were back/spine/vertebrae (11%) and bone including knee (11%; Figure 5).

Of the 52 accidents that occurred when moving/sorting of cattle were the 20 cases (at 38%), which led to a sick leave longer than 14 days, and 8% of which led to some degree of medical disability.

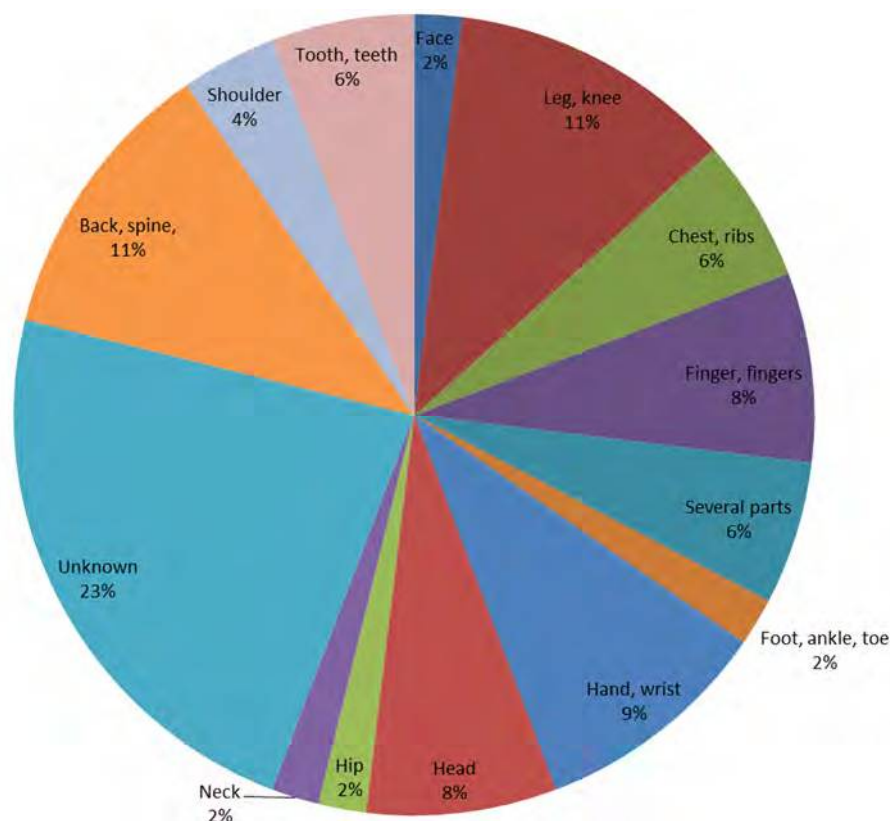


Figure 5. Injured body parts in the accidents incurred during remove/sorting of cattle.

Milking

56 occupational accidents occurred during milking. Cow or heifer was external injury factor in 93% of accidents. In 64% of cases was the damage by kicked, and another common event was that the person was pinched. Typical cases of accidents in milking were:

- During milking, the person was kicked out by the cow and fell down in the gutter, and then broke her hand
- Put on milking organ and would prepare the cow for milking. Was kicked out of the cow. Kicking against the rear head which results in severe headaches
- Con settles in milking, pinched hand
- Met a cow in a narrow time, was pinched between the cow and the wall

In milking, hand/wrist was the most abundant injured body part with 25% of the damage (Figure 6). Generally, the upper extremity was particularly affected during milking. Of the 56 occupational accidents which occurred at milking were 22 cases, or 39%, which led to a sick leave beyond 14 days and 7% which led to some degree of medical disability.

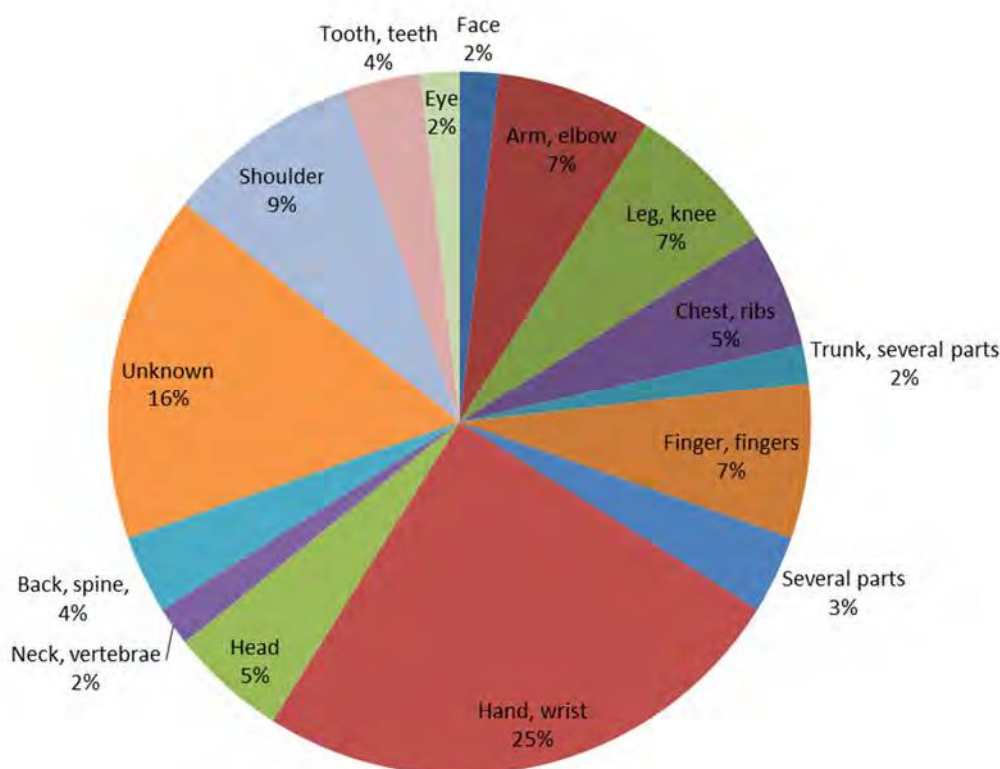


Figure 6 Injured body part in the accidents occurred during milking (56 cases).

Work with horses

88 occupational accidents occurred at work with horses. Normal operation when the accidents occurred was leading/moving horse (43%), horse riding/running horse (30%), production/shoeing (7%) and treatment (e.g. put on sores, worms; 7%). Common events was kicked (26%), from the horse at horse riding (24%), trampled, over on ran and pinched. Examples of accidents at work by horse were:

- Rowdy foal kid who tried to tear himself away. Kept both foals kid and strain as early as attempted to close a gate. Foal kid jerked to the rope which the person gave in and then broke the finger
- Leading a horse. care of the horse, hard kicked in the back
- Put on a wound on the leg of the horse, the horse put down the hoof on the finger
- Held in the young horse that would be affected, the horse got scared, throw themselves, squeezing hand against wall

- While were leading horse. Horse were afraid of lawn mowers, pinched between the input and the horse
- She rained/rode a horse. The horse stumbled and the horse and the person both went down, she landed in the horse

When worked with horses, hand/wrist, fingers and legs including knee were the most common damaged body parts with 13%, 11% and 11% of the damage (Figure 7). Of the 88 occupational accidents which occurred at work with horse were the 37 cases, or 42%, which led to a sick leave beyond 14 days and 19% that led to some degree of medical disability. There were largely young women to be injured, close to two-thirds of those injured were under the age of 35 years and 38% were under the age of 25 years.

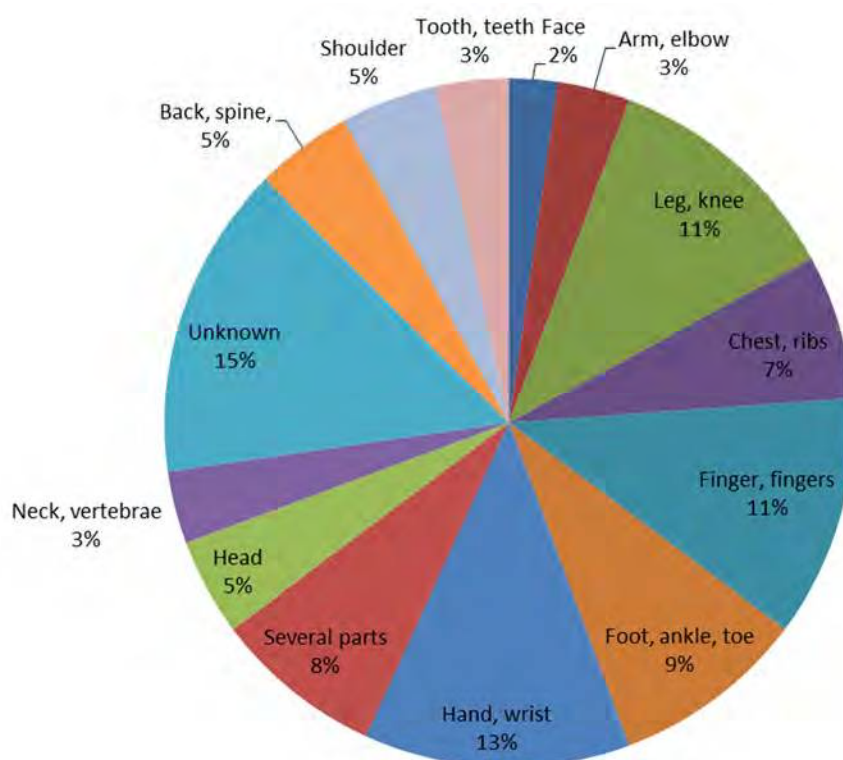


Figure 7. Injured body part in the accidents occurred during work with horse (a total of 88 cases).

Discussion and conclusions

The results of this study showed that the number of accidents in agriculture steadily increased in the period from 2009 to 2013. The accidents were most associated with milking, moving/sorting of cattle, other cattle management and work with the horse. Close to one in five accidents was also related to horses. Horses made up a large and growing business in the agricultural enterprises and working with horses was largely female dominated. Feeding and cleaning/strewing were also the operations with relatively much accidents and high proportion of animal-related accidents.

The most common accidents that occurred in milking, moving/sorting of cattle, other cattle management and work with the horse, had a higher proportion of cases that led to a sick leave longer than 14 days. Work with horses had a twice the proportion of work-related injuries that led to medical disability, compared to the three work phases with cattle. Nearly

one in five who was injured when working with horses got permanent physical disabilities, however the detailed information about these cases are still missing in the database. Because of the high proportion of animal-related injuries, the preventive measures should focus primarily on this group of injuries. The analysis of these injuries will be continued to gain the more detailed information of the underlying causes and suggest the more specific measures.

The young women were particularly affected by accidents at work, then more than a quarter of those injured were under the age of 25 years and 46% of them were under the age of 35 years. The question is whether this is due to the fact that young women are exposed to greater risks, or if the allocation simply mirrors the age distribution of women employed in agriculture? A possible reason for young women at higher risk of being involved in an accident at work can be that they have less experience and professional knowledge, but it can also be explained in that they are exposed to greater risks when it is common that they are working with cattle and horses. 82% of accidents for young women < 25 years affected women in professions related and horse trades attesting this interpretation. It is also possible that there is a greater tendency of young women to report an accident.

Acknowledgements

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Psychosocial condition and mental health of Swedish farmers and rural entrepreneurs

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Introduction

The expansion of small family farms often implies increased financial responsibility, risk taking, employer responsibility and long working hours. Agriculture represents a profession whose success is highly dependent on uncontrollable external conditions such as weather, legislation, disease outbreak, environmental changes and negative societal attitudes. Moreover, farmers' face normative and market pressures and are expected to maintain high production standards, a stable economy and to act in socially conscious and environmentally responsible ways. The combination of uncontrollable external factors, increased expectations and weak social support may cause poor psychosocial working conditions and ultimately a decreased mental health.

Aim

The objective of this study was to examine the psychosocial working conditions and mental health of farmers' operating small size Swedish farms with different production sectors such as crop, dairy, beef and pig.

Methodology

The study was conducted in 2010-2011 among 470 farmers comprising 177 crop farmers, 139 dairy and beef farmers and 154 pig farmers. The General Nordic Questionnaire for Psychological and Social Factors at Work (QPSNordic) was administered to assess subjective perceptions of the psychosocial work conditions and mental health.

Results

The three groups reported general well-being regarding their psychosocial work conditions and health, however, dairy and beef farmers perceived their psychosocial work conditions and mental health as worse compared to crop and pig farmers. This was characterized by higher work demand, more negative impact regarding work and leisure time, less contentment concerning how the dairy and beef farmers dealt with the physical and psychosocial work demands, worse general health and more exhaustion after a work day. The participants were asked about the extent to which they felt stressed by various external factors. The external factors that especially crop farmers and dairy and beef farmers experienced as most stressful was the EU legislation, comprehensive subsidy regulations, lots of governmental and EU-related controls and delayed payments, and the Swedish authorities' attitude towards farmers. Increased demands on environmental issues, from society and consumers, weather conditions, animal welfare legislation, varying market prices, increased crime in rural areas, agro-terrorism, disease outbreaks among plants and animals and concerns for the future of the farm were other external factors that were stressful for the farmers. Based on the results, an action plan for improvement of the psychosocial working conditions, mental health, and social support in rural areas should be the next step to be developed.

Sustainable health and safety of Ugandan farmers

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Introduction

‘Sustainable agriculture’ and food security requires ‘sustainable health’ and safe working conditions for farmers and farm families. Farmers in good health will be able to provide for their families and contribute to the local farm community. There is limited or almost non-existing research available regarding health and safety of farmers in Africa and data is essential to understand and change patterns of human health and safety. In Uganda, these issues are not considered from an agricultural aspect although the majority of risk factors regarding human health and safety are related to agriculture.

Aim

The objective of the study was to interview Ugandan farmers and family members regarding their attitudes towards health, safety and risk factors in an agricultural context, and how it affected their daily lives and livelihood.

Methodology

The study was conducted in Uganda May 2014 and comprised interviews with seven male and female farmers, and transects walks on each farm.

Results

In general the level of knowledge and awareness of agricultural health and safety risks, disease and injury prevention among the farmers was low. The farmers claimed few agricultural related complaints, injuries or diseases. It was obvious from the farmers’ responses that health and safety concerns (e.g. diarrhea, cough, fever), cuts while using the machete in the plantation, bruises when handling the animals and symptoms of poisoning from using insecticides on the

animals were nothing worth talking about and considered as part of the occupational hazard. The most important topic mentioned by the farmers was the use of chemicals and drugs related to livestock. Once a week the farmers sprayed the animals with an insecticide to prevent ticks, lice, tsetse flies and other biting nuisance flies using a back or hand sprayer. The spraying was conducted without personal protection equipment (PPE) which was considered too expensive and difficult to obtain. The farmers explained that they usually felt unwell, dizzy, vomited, and had pain and burning feeling in the face and eyes after spraying. Sometimes the symptoms were so severe that they needed treatment and bought medication without prescription at the local drugstore where the storekeeper often had limited or non-existing knowledge about the chemicals or drugs, except for dosage.

The availability of agricultural health and safety training in the region was non-existing and the farmers expressed the need for information and practical training in agricultural health and safety, disease and injury prevention.

A survey on occupational injuries in tree climbing in Italy

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Abstract

The aim of this work is to know how many injuries occur to tree climber arborists, during their pruning and felling work on tall trees, both to know what kind of accidents and the reason why them happens. This study was made by means of "INFORMO", an INAIL's database which contains a list of serious and fatal injuries occurred from 2002 to 2012 counted by INAIL's Prevention Service. From such list Authors extracted only accidents related to operators who was working on tall trees, at least 2 meters above a stable ground, without using lifting platform. In these case operators would have to use ropes and harness. The result of the study consists in understanding common triggers of injuries, knowing if there are technical problems that can be solved, or other problems that can be addressed to decrease the number of accidents and their severity.

Keywords: Arboriculture, Work at Height, Safety And Health

Introduction

The presence of trees within the city, private gardens and parks is now recognized as a necessity and added value to the quality of life for the assimilative capacity and store carbon, oxygen emission, mitigation summer heat, thanks to the shadow produced by the foliage and water vapor caused by evapotranspiration, not taking into account the high landscape value. These benefits, however, entail the burden of maintenance, including:

- a proper assessment of the needs of the trees (airspace, radical);
- control of diseases (fungal, bacterial, insect infestations);
- the pruning.

The latter, which allows to reach the best compromise between the tree growth and the traffic's needs and safety along with the space limitations, must be done by green areas management professionals, because of their knowing about plants biology and the reactions of various types of pruning to the tree, depending on its species and age. Besides the professional green they must know the operating procedures to perform the pruning, in order to work efficiently and safely.

In this work accidents occurred in this workplace in Italy have been investigated, especially for pruning of tall trees, or during operations on trees that provide movements of the operator above two meters in height from a stable work plan, without the aid of a lifting platform but only through the use of ropes and safety harnesses.

Such technical work in canopy is called "tree climbing": due to its characteristic it is used all those times when you can't reach the target tree with a lifting platform, or when pruning or consolidation of branches is required to be executed from within the crown, and it is only feasible with this working technique. The aim of this survey consists in understanding what are the most common injuries in this kind of work and consequently what are the measures to limit the occurrence or diminish the severity of the consequences.

Methods

The data subject of this paper have been extracted from the database INFORMO, made by INAIL ('Istituto Nazionale per l'Assicurazione contro gli Infortuni sul Lavoro'), available on the web at "<http://www.ispesl.it/getinf/informo/>". Inside it there are over 3800 dynamic of accident, which took place between 2002 and 2012, analyzed by the prevention services with a shared analysis model. In the "Archive of cases" you can search for areas of interest using the available filters; you can also make a free search with keywords using a search engine. With the said method, all injuries related to the word "tree" have been researched, and the search engine generated a list of 166 cases, which were analyzed individually to find the correspondence with the type of work investigated. Of these, 21 cases were eligible to the survey, because about pruning or felling of tall trees (else working over two meters height from the stable ground) without the use of platforms and using a positioning system with ropes and harnesses.

The INFORMO database classifies accidents with an alphanumeric code. Each event is associated to a brief description and different cards: the first one consists in the detailing of the accident. It lists the characteristic data of the incident's place, the injured, company and consequences. The second one shows the details of the injury factor. Finally there may be a third and a fourth table if together with the determinant there were one or more modulators factors that have influenced the development of the accident.

Results

From the data obtained in this analysis, looking at the modal data of each category (table 1), the profile of the standard worker more susceptible to injury comes out. It appears that falling from height is the most common trigger of injury, always with fatal consequences. Other data are reported in the table.

The profile shows that the operator more prone to injury is an Italian male, with a low level of education, working independently in agriculture, with experience in his work. The problem lies in the fact that pruning or felling of tall trees, even if present in agricultural environments, cannot be carried out by agricultural operators. They are specialized and normed by law (D.Lgs. 81/08 in Italy) activities that can be performed only after completion of enablers training. In fact, the determining factors are always procedures errors: the operator did not know what exactly he was doing, or how best to do, nor what were the consequences in case of failure. It also results from the risk assessment carried out by the injured: "factor not assessed".

Also aggravating modulator factor (but also in the background among the determinants) is the non-use of protective equipment such as helmets and restraint systems with ropes and harnesses.

Conclusions

In conclusion, there are laws that clearly establish who can perform work on ropes on trees (treeworkers), there are technical texts that refer to the safest working techniques and many safety devices dedicated to this type of work are available on the market.

The problem behind these accidents is the lack of training, and even before the issue of Italian culture, where everyone can do everything, but actually you have to have specific skills to perform complex jobs.

Even the assessment of the difficulty of operations must be performed by a technical expert in the sector, able to recognize specific problems.

The first point to be developed to reduce accidents and their severity is definitely the spreading of the safety culture, followed by proper training.

Table 1. Summary of modal value obtained from the survey in the INFORMO database

Categories	Modal data
Summary description	Fall from height
Ordinal working time	2-3
Collective accident	No
Place of injury (body)	Skull
Nature of injury	Fracture
Time off days	7500
Education	Middle school diploma or start training
Gender	Male
Nationality	Italian
Employment	Independent without wmployees or holder Without employees
Task	Farmers end specialized agricultural workers
Length of service	> 3 years
Number of employees present on the site with the patient	1
Business activies	Agricultural crops, horticulture, floriculture, breeding
Place of injury (location)	Agricultural site, orchard
Subcontract Y/N	No
Task of the injured at the moment of accident	Own work activities
Parts of the environment that have impacted to body	Ground
Type of accident	Energy variation
Material cause	Plants
Determinant 1	Activity of the injured
Safety problem (Det. 1)	Error of procedure - Improper practice tolerated
Comparison with standard	D.Lgs. 81/2008
Risk assessment	Factor not assessed
Determinant 2	PPE
Safety problem (Det. 1)	Error of procedure
Modulator Factor	PPE and clothing

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Health and Safety Challenges among Dairy Workers in the United States

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Abstract

Dairy farming is among the most dangerous agricultural settings. The purpose of this study was to describe the work experiences of dairy workers in the United States (U.S.) to design appropriate safety training programs. The long-term goal of the work is to eliminate occupational injuries among a vulnerable (primarily Latino) workforce in industrialized dairy operations.

Focus groups were conducted before or after work shifts. Workers were asked to describe their work experience at the dairy, quality of relationships with their coworkers and manager/s, as well as safety policies and procedures, and training experiences. Focus groups were conducted in Spanish and required approximately one-hour. Discussions were recorded, transcribed and translated into English, and analyzed for themes. Forty-four dairy workers participated.

The workers described their jobs as highly stressful, characterized by strenuous manual labor and time pressures. Participants reported many equipment issues and environmental hazards on the dairy, including exposure to unsafe conditions and numerous harmful substances. Relationships with co-workers were generally described as positive and team-oriented, while relationships with managers were more varied and negative. Participants reported limited knowledge regarding safety policies and procedures and made numerous suggestions for how to improve safety training.

The participants identified individual, organizational and environmental points of intervention that can be used to inform management and training programs in order to promote and maintain a higher level of safety within the U.S. dairy industry.

Keywords: Occupational Health, Dairy Workers, United States

Introduction

The dairy industry in the U.S. produces a substantial amount of the world's milk supply (International Dairy Federation, 2010). In recent decades, the industry has been shifting toward a high efficiency model with growing herd sizes driven by advances in milking technologies (Doughrte et al., 2013). With the trend towards large-scale industrialized operations, U.S. dairies are increasingly relying on immigrant, primarily Latino, workers (Schenker & Gunderson, 2013).

The dairy industry has been recognized as one of the most dangerous agricultural settings, with high rates of occupational injuries and illnesses (Hagevoort et al., 2013). The promotion of health and safety are high priorities for dairy industry leaders, yet there has been very little research to date on the determining factors of these outcomes among immigrant Latino dairy workers (Hagevoort et al., 2013). In order to advise the development of culturally sensitive training programs, the present study conducted focus group interviews to better understand dairy worker perceptions of the barriers to and facilitators of enhanced safety.

Materials and methods

Dairy owners from three U.S. dairies were recruited and agreed to allow their workers to participate. Owners announced the opportunity to workers and encouraged them to participate by posting recruitment flyers in both English and Spanish. Eligibility was restricted to Latino/a dairy workers.

Focus groups (approximately one-hour in duration) were conducted on-site at each dairy before or after work shifts. Participants were asked questions about their previous and current work experiences. They were also asked to describe the quality and nature of relationships with their manager/s and co-workers. The interview closed with a discussion of safety policies, procedures and training. All focus groups were conducted in Spanish by a bilingual member of the research team. An interview guide was used to lead the discussion, while also maintaining flexibility to allow the workers to bring up other topics perceived as important. Confidentiality and anonymity were assured, and no demographic information was collected. However, some basic demographic and background information, such as gender, length of time working in the dairy industry, and country of origin, was gathered anonymously during the interviews. All participants provided written consent before initiation of the focus groups. Workers were incentivized to participate with a small gift certificate to a local store.

All discussions were audio-recorded, translated into English and transcribed verbatim with the help of a bilingual research assistant. Transcripts were analyzed by the first and third authors to identify themes. All discrepancies were discussed until consensus was achieved on the final list of themes.

Results

A total of 44 dairy workers (9% female) participated in the study. Participants were primarily from Mexico, but there were also representatives from Puerto Rico as well as South and Central America. The prevailing themes identified were grouped into the following categories: the nature of the work, equipment issues, environmental hazards, relations with coworkers and managers, and safety policies, procedures and training.

The workers' jobs involved manual labor, time pressure and stress. Participants reported numerous equipment issues (e.g., broken machinery, lack of personal protective equipment) as well as various environmental hazards (e.g., exposure to electricity, chemicals, manure, dust, polluted water) that influenced safety and health outcomes. Participants described relations with co-workers as positive and team-oriented, although some noted tensions due to poor irresponsible behavior and poor performance. Participants described the quality of relationships with their managers as anywhere from positive to negative to non-existent. Participants reported limited knowledge regarding safety policies and procedures, perceived safety training to be insufficient, and made numerous suggestions for enhancements.

Conclusions

This study provides novel and in-depth insights into the attitudes, beliefs and experiences of immigrant Latino workers on U.S. dairy farms, with a particular focus on safety. The participants identified numerous points of intervention—across individual, organizational and environmental levels—for better organizing, managing and training immigrant dairy workers in order to creating a more safe working environment.

Overall, the workers expressed a desire for more respect and acknowledgement as well as better integration across the different areas of the dairy. High workload and scheduling

issues were acknowledged as especially stress-inducing aspects of the job, suggesting considerable effort should be invested into reducing these stressors. Participants highlighted the importance of more quickly addressing environmental hazards and equipment issues to avoid putting animal and human health at risk. There was a shared belief among participants that dairy management tended to prioritize cow health and safety over that of workers. This belief has been found in other studies involving immigrant Latino dairy workers in the U.S. (e.g., Arcury et al., 2010). It is essential that dairy management work to promote a strong safety culture. Many participants requested additional personal protective equipment, particularly in the milking parlor and other high-risk areas of the dairy. It is important that the introduction of new personal protective equipment be accompanied by instructions and training regarding proper use.

The increasing reliance on an immigrant, primarily Latino, workforce within the U.S. dairy industry, calls for the development of culturally-relevant and evidence-based safety programming. It is important such programs be guided by workers' attitudes, beliefs and behaviors in order to ensure maximum effectiveness (Blancero, 2014). These findings serve as an initial step toward better understanding how to improve safety outcomes among immigrant dairy workers.

Acknowledgements

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A Certificate Course for the Agricultural Safety & Health Profession

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Aims

In 1996 a Certificate Course in Agricultural Medicine was designed by a multidisciplinary consensus group in the U.S., primarily for health care providers. This course has expanded to 9 states in the U.S., Australia, and Turkey. A similar course for agricultural safety and health professionals has not existed. The objectives of the Agricultural Safety and Health Certificate Course were to: 1) Identify subject matter appropriate as core knowledge for practicing agricultural safety and health professionals; 2) Develop learning objectives for the core subject matter; and 3) Offer a pilot Agricultural Safety and Health Certificate Course.

Methodology

A task force of the International Society for Agricultural Safety and Health (ISASH), in exploring enhancement of professional development activities for members and others, used the agricultural medicine course as a starting point and decided upon a 3-day course taught by highly respected instructors focused on the following subject matter content areas: 1) History of Safety and Health in Production Agriculture; 2) Agricultural Operations and Workers; 3) Injury and Illness in Agriculture; 4) Agriculture Injury Hazards; 5) Agricultural Illness Hazards; 6) Methods and Approaches to Hazard and Risk Management; 7) Personal Protective Equipment; 8) OSHA and Other Safety and Health Regulations; 9) Developing Safety and Health Management Plans; 10) National Approaches to Agricultural Safety and Health; 11) International Approaches to Agricultural Safety and Health; and 12) Resources and References for Hazard and Risk Management.

The specific target audiences for the course were determined to be: 1) Beginning agricultural safety and health extension specialists, researchers, rural health care providers, administrators, loss control specialists, risk management specialists, and those with similar titles; 2) Farm and ranch operators, managers and supervisors responsible for worker safety and health; and 3) Practicing safety and health professionals missing formal training in agricultural safety and health.

An online course evaluation, operated by the University of Nebraska Medical Center, was devised. Students are required to pass a 50 item individually-randomized test with a score of 70% or higher. The exam was open-book and students may take the exam up to three times but must wait at least one week between each attempt. Financial support from the Agricultural Safety and Health Council was obtained to minimize the course fee.

Partial Results

Twenty-four students have completed the pilot course. Testing and course evaluation is in progress on the due date of this extended abstract. Final results, evaluations and conclusions will be presented on the poster.

All 24 students (100%) opted to take the exam to obtain a certification by examination which indicates competency in core knowledge in agricultural safety and health. A copy of the certificate to those passing the exam is shown in Figure 1. To date, 8 of 24 students

(33.3%) have completed the exam with 8 (100%) successfully meeting requirements for certification. Sixteen of 24 students (67%) have completed the course evaluation. Of those completing the evaluation, 14 of 16 (87.5%) were practicing professionals with the other 2 (12.5%) participants identifying as graduate students.

A sliding scale (0-100) was used to evaluate several specifics of the course. A mean of 77 (52 min; 98 max) was received when asked if the course achieved its overall purpose of establishing a core level of knowledge in the agricultural safety and health profession. To the question about how well the course achieved its objectives to enable the participants to recognize and understand the major occupational health and safety issues in agriculture, a mean of 78 (40 min; 98 max) was received. When asked if the course helped the student anticipate, recognize, and prevent occupational, environmental and community health and safety problems unique to the rural and agricultural populations, the mean was 77 (56 min; 97 max). For the question about the course providing multidisciplinary and community oriented prevention solutions to health and safety problems, the results show a mean of 75 (50 min; 99 max).

Students were asked to evaluate the value and usefulness of the specific subject matter taught in the course by asking them to use the sliding scale. Evaluations to-date on the major topics is summarized by mean, minimum and maximum scores.

Topic	Mean	Minimum	Maximum
History of Safety and Health in Production Agriculture	80	57	97
Agricultural Operations and Workers	79	60	95
Injury and Illness in Agriculture	75	50	95
Agriculture Injury Hazards	78	55	95
Agricultural Illness Hazards	79	55	95
Methods and Approaches to Hazard and Risk Management	81	21	100
Personal Protective Equipment	87	65	100
OSHA and Other Safety and Health Regulations	73	0	100
Developing Safety and Health Management Plans	83	35	100
National Approaches to Agricultural Safety and Health	75	13	95
International Approaches to Agricultural Safety and Health	70	13	100

Students were asked to indicate if their background was primarily safety, health, or a combination of both. Six students (37.5%) indicated a safety only background while 10 students (62.5%) indicated their background included both safety and health. No one indicated a health only background. When asked if the instructors tried to cover too much material in a 3-day course, the responses were evenly split between Yes (8, 50%) and No (8, 50%). Students were asked how important it was to have an opportunity to obtain a certificate based upon successful completion of an examination. The mean response was 86 with a low value of 17 and a high value of 100. Student were also asked if they would recommend this course to a colleague in the agricultural safety and health field with 15 of 16 respondents (94%) saying Yes.

Fewer students (8 of 24, 33.3%) have completed the examination as this time. A score of 70% is required to pass the examination. All have students have successfully passed the exam for certification with a mean score of 84. The low score to-date is 76 and the high score is 90.

Overall, it appears that the Agricultural Safety and Health Certificate Course meet the expectations of a large majority of participants. The number of students enrolled in the pilot test and their interest in completing the examination for certification suggests that professionals are interested in certification in agricultural safety and health. All students highly recommend that other professionals take this certificate course. Additional evaluation results will be included on the poster. Evaluation results, once completed, will be utilized by the course instructors to revise future course content and structure.



Figure 1. An image of the Certificate of Examination for the Agricultural Safety and Health Certificate Course.

Community Engagement in the Prevention of Injuries and Deaths from Agricultural All-Terrain Vehicle Use

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Introduction

All-Terrain Vehicles (ATVs) have become an essential aspect of efficient agricultural work but have led to many injuries and deaths. Since 1982 over 12,000 people have been killed in the United States riding ATVs for occupational and recreational uses (CPSC, 2014). ATVs are used in farm and ranch operations with increasing popularity resulting in 65% of all occupational related deaths occurring in the agricultural sector (Helmkamp et al., 2012). Occupational use of ATVs (Figure 1) is on the rise in many sectors because of their versatility, adaptability and affordability but has led to a nearly 200% increase in work-related fatalities reported in the U.S. between 1999 and 2008 (Helmkamp, 2011).

Practice Innovation

During challenging economic climates, it has become necessary for researchers and agricultural associations to work together as partners in the prevention of injury and deaths related to occupational ATV use. Using social marketing concepts and methods (Kotler et al., 2002), we developed a series of projects to increase the number of certified ATV safety trainers serving rural agriculture communities throughout the state of Montana. We designed participatory, community partner led projects for successful translation of ATV safety training through the Agricultural Extension Model to serve end users. The Agricultural Extension Model has been identified as one of the most successful approaches to translation of science to practice and adoption of research results (Rogers, 2003). Within this framework, theories work behavior (Campbell et al., 1993), planned behavior (Ajzen, 1991), the organization of work model (NORA Organization of Work Team, 2002), as well as social marketing principles were incorporated to enhance effective translation and dissemination of agricultural health and ATV safety knowledge, skills and abilities to end users. University researchers partnered with 11 agricultural Extension Agents in Montana. The partnership resulted in training and certification (by the ATV Safety Institute - ASI) for all 11 Agents located in rural areas throughout the State. The Agricultural Extension Service is made up of effective ‘change agents’ from communities throughout Montana. These agents live and work in the rural communities and provide support services for Agricultural operation success, they enjoy unique personal and professional relationships with operators and are perceived to be credible. Agents routinely promoted safe ATV use became certified to teach the five-hour ASI hands-on training in their communities with a focus on safe use for ranching work as opposed to recreational use. The Extension Agents were able to recruit agricultural producers through local communication channels for hand-on training in their communities. A series of trainings was launched in 2014 and continues throughout rural locations in Montana with increasing numbers of agricultural producers researched.



Figure 1. ATV used in ranching for tasks associated with fencing building, spraying weeds and herding animals.

Results

Certified Agricultural Extension Agents have trained over 75 producers to date. Evaluation of training sessions have enabled researchers to understand more about the specific needs of the producers, barriers and facilitators related to safe ATV use, and perceptions about ATV use in agricultural operations. ATVs among Montana ranching operations are used for general transportation, cattle handling, fence mending and weed control. Barriers exist to adoption of formal training and helmet use. We have found that the 5-hour ASI training overcomes many misperceptions and barriers about training and helmet use. Our data revealed that 88% of agricultural producers reported the training definitely increased their awareness of ATV safety issues and will alter their behavior. Using a pre/post test design with the trainees in the ATV safety program, we found 15% measurable gains in ATV safety knowledge and 100% of trainees reported the issues taught were applicable to their work. Producers indicated that they were likely to recommend the hands-on training to other producers as a result of their experience.

Additional outreach partnerships with Montana agricultural producers have resulted in ATV safety information Tip Sheets containing safety information aimed at the four primary uses of ATVs on cattle ranches, see Exhibit 1. These Tip Sheets were developed using participatory research to practice (R2P) model with community partners to enhance local messages about safe ATV use and to increase adoption of ATV the 5-hour hands-on field training. The Tip Sheets were disseminated throughout rural Montana. Feedback from Agricultural producers indicated an increase in safety knowledge and 74% would change the way they operated their ATVs as a result of information on the Tip Sheets.

Agricultural Extension Agents were interested in additional portable tools for ATV safety field training. Durable ATV Safety Training Kits were developed for Agricultural Extension Agents that had taken the 5-hour hands-on training and/or obtained ASI

certification. Thirty ATV Safety Training Kits were produced and disseminated to 30 Agricultural Extension agents to use under variable environmental conditions. The kits contained posters, placards, flip cards, tip sheets, slide presentations, additional handout and evaluation forms. Data is being collected on the effectiveness of this tool for ATV safety training.

An additional partnership between media and web technology professionals at the university has resulted in the development a culturally appropriate, 60 minute, web 2.0 interactive training/education experience conceived and designed by certified Agricultural Extension Agents. This training/education is aimed at increasing awareness of risk and hazards associated with ATV use in ranching operations and the need to be knowledgeable about safe vehicle use and operations: 1) pre-ride vehicle safety check, 2) personal protective equipment, 3) starting and stopping, 4) driving on uneven terrain, 5) navigating obstacles and 6) riding up, down and across hill sides. The training and education are also reinforcing the need to take the 5-hour hand-on ASI training to achieve maximum learning, competency and safe vehicle operation.

The most recent project will deliver Public Service Announcements (PSAs) about ATV risks, hazards and available training in the local community. The PSAs will be disseminated throughout communities using multiple communication platforms while promoting a culture of adoption for ATV safety training and safe use in agricultural operations.



Figure 2. ATV used for herding cows.

Conclusions

The effective partnership between university researchers and agricultural partners has led to Agricultural Extension Agents earning ASI certification in safe ATV use on the farm and significantly increased capacity and access to high-quality ATV safety training for ranchers in rural Montana. Certified Agents must provide two training sessions per year to sustain their certification. Each session trains between six and eight producers resulting in a guarantee of 132 – 176 producers being trained each year in safe ATV operations throughout Montana. The success and sustainability of this project was only possible due to the strong collaboration and resources that each partner contributed to the project

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TOPIC 6

“Environment Safety, People Health Protection and Welfare”

Italian Potential Biogas and Biomethane Production from OFMSW

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Abstract

This work is aimed at predicting the potential biogas and biomethane production, using the Organic Fraction of Municipal Solid Waste (OFMSW), in Italy, where 1388 Anaerobic Digestion (AD) plants (power of 7.4 TWh, equal to 640.4 ktep) are nowadays available.

In order to compute the potential biogas and biomethane production in the 20 Italian regions, the data about OFMSW production in 2010-2013 period have been evaluated.

The Italian production of OFMSW, that was 5.2 million tons in 2013 (18% of MSW), could be used inside bioreactors for producing biogas and digestate, that must be aerobically composted into a biofertiliser. In 2013, the Italian potential biogas production from OFMSW was 739 million m³, that is equal to 444 million m³ of biomethane. The highest biogas production from OFMSW was in Lombardy region (143 million m³), having a potential biomethane production of 86 million m³. The highest OFMSW production per inhabitant was in Emilia-Romagna region (142 kg). Yet, if OFMSW was 37% of MSW, the potential biogas and biomethane production should be increased: the biomethane production increase would be 486 million m³, of which the maximum would be in Sicily region.

The biogas produced can be used for generating heat and electricity or upgraded into biomethane, distributed at dedicated stations and useful as biofuel for powering means of transport. This biofuel would replace natural gas, and, therefore, allow a reduction of GreenHouse Gas emissions of 200 g of CO₂ kWh⁻¹ (5.5 times lower) and the import of fossil fuels from abroad.

Keywords: Organic Waste, Anaerobic Digestion, Biofuels, Biofertilisers, Greenhouse Gas Emissions

Introduction

The Anaerobic Digestion (AD) is the technology that can convert food industry by-products and/or the Organic Fraction of Municipal Solid Waste (OFMSW) and/or sewage sludge into renewable energy inside a bioreactor (Molino et al., 2013). AD process consists of a series of metabolic reactions (i.e. hydrolysis, acidogenesis, acetogenesis and methanogenesis), performed by a wide range of microorganisms in low or no oxygen environments and producing biogas and a digested substratum, called digestate, that must be aerobically composted into a biofertiliser (Comparetti et al., 2013a; Molino et al., 2013).

The biogas produced from AD process contains mainly methane (60% ca.) but also carbon dioxide, hydrogen, hydrogen sulphide, ammonia, siloxane and other substances that may inhibit the AD process itself or cause corrosion problems in plant pipelines or in distribution networks (Karatza et al., 1996; Lancia et al., 1997; Chen Ye et al., 2008).

The biogas produced can be used for extracting biomethane, that can be transferred to the national natural gas distribution grid or distributed at dedicated stations (to be built in the same area of each AD plant) and used as biofuel for powering means of transport. Another option is to transform the above biogas into electric and/or thermal energy inside a CHP

(Combined Heat and Power) plant, in order to contribute to replace fossil-oil based energy sources with renewable ones (Molino et al., 2013; Comparetti et al., 2013b).

Several authors have summarised technologies for biogas purification, aimed at extracting biomethane, by removing hydrogen sulphide, ammonia and siloxane. At the end of this process the biogas still contains hydrogen, carbon dioxide and traces of sulphidric acid and ammonia (<100 ppm), that must be removed from the stream, in order to produce biomethane (IEA, 2007).

The above process of upgrading biogas is a carbon negative balance, because the biomethane replaces the fossil natural gas and the carbon dioxide can be captured and used in industrial processes (Nova Energie, 2015).

OFMSW can be treated together with other organic wastes (co-digestion), e.g. animal manure, sewage sludge and wastes of slaughterhouses, in order to minimise the problems related to the collection of all co-digested wastes, i.e. bad smell (due to the concentration of proteins and sulphuric compounds, that become lower after AD) and high concentration of nitrogen (Comparetti et al., 2012).

The effective management and treatment of biodegradable waste is a topic of increasing importance for municipalities all over the world (Browne and Murphy, 2013).

OFMSW, which is dominated by food waste, is problematic as it is putrescible: it contaminates recyclable materials in combined waste collection methods and releases methane to the atmosphere, when it is deposited in landfill sites. Methane has a Global Warming Potential (GWP) 23 times that of carbon dioxide in 100 years (IPCC, 2012) and significantly contributes to climate change. The Landfill Directive 1999/EC (Directive 1999/31/EC, 1999) has established significant targets for reducing the biodegradable waste conferred to landfills, while the Waste Framework Directive 2008/EC has introduced more demanding waste recycling and energy recovery targets (Directive 2008/98/EC, 2008). Many EU countries have introduced landfill taxes, while some countries, including Germany, have established an outright ban on dumping untreated OFMSW.

The Landfill Directive 1999/EC permits, by 2016, landfills having a maximum storage capacity of 420,000 t/year of biodegradable municipal waste (based on 35% of 1995 amounts), so that alternative waste treatment methods are required for approximately 530,000 t/year of this waste (Directive 1999/31/EC, 1999).

AD is an environmentally effective waste treatment, whose added benefit is energy recovery in the form of biogas (Mata-Alvarez, 2003). The EU Renewable Energy Directive 2009/EC indicates that biomethane from OFMSW has a nominal GreenHouse Gas saving of 80% rather than the displaced fossil fuel (Directive 2009/28/EC, 2009), when it is used as a compressed gaseous biofuel. This saving is higher than other first generation liquid biofuels (Korres et al., 2010).

This work is aimed at predicting the Italian potential biogas and biomethane production, using OFMSW in a country where 1388 AD plants (total power of 7.4 TWh, equal to 640.4 ktep) are nowadays available (GSE, 2015).

Materials and methods

In order to compute the potential biogas and biomethane production in the 20 regions of Italy, the data of ISPRA (Higher Institute for the Environmental Protection and Research) Waste Register about OFMSW production in 2010-2013 period (2015) have been evaluated.

The potential biogas production per year from OFMSW (B_{OFMSW}) was determined according to the following equation, based on the biogas yield (bw) and the mass of this fraction produced per year (m_w) (Marangoni et al., 2013) :

$$B_{OFMSW} = b_w m_w \quad (\text{Eq. 1})$$

where : b_w is the biogas yield of OFMSW ($\text{m}^3 \text{t}^{-1}$);
 m_w is OFMSW mass (t).

The potential biomethane production per year from OFMSW (BM_{OFMSW}) was determined according to the following equation, based on the biomethane content of OFMSW (mc_w) and the potential biogas production per year from this fraction (B_{OFMSW}) (Marangoni et al., 2013) :

$$BM_{OFMSW} = mc_w B_{OFMSW} \quad (\text{Eq. 2})$$

where : mc_w is the biomethane content of OFMSW (%);
 B_{OFMSW} is the potential biogas production per year from OFMSW (m^3).

Results

The Italian production of OFMSW, that was 5.2 million tons in 2013 (18% of MSW), could be used inside bioreactors, eventually together with other raw materials, in order to produce biogas and digestate. In 2013, the potential biogas production from OFMSW in Italy was 739 million m^3 , that was upgraded into 444 million m^3 of biomethane. The highest biogas production from OFMSW was in Lombardy region (143 million m^3), having a potential biomethane production of 86 million m^3 . The highest OFMSW production per inhabitant was in Emilia-Romagna region (142 kg) (Table 1).

Yet, if OFMSW was 37% of MSW, as it should be, the potential biogas production would be 1550 million m^3 (Table 2), that is similar to 1330 million m^3 , estimated by Marangoni et al. (2013). Therefore, the MSW transferred to landfills would be reduced by 19% and also this amount could be converted into biogas and digestate.

Table 1. Italian potential biogas and biomethane production based on the actual OFMSW mass in 2013 (ISPRA, 2015)

N.	Region	Inhabitants (10 ³)	MSW (10 ³ t)	OFMSW (10 ³ t)	OFMSW per inhabitant (kg/person year)	Potential biogas production (10 ⁶ m ³ /year)	Potential biomethane production (10 ⁶ m ³ /year)
1	Abruzzi	1334	600	119	89	17	10
2	Basilicata	578	207	17	29	2	1
3	Calabria	1981	833	35	18	5	3
4	Campania	5870	2545	618	105	87	52
5	Emilia- Romagna	4446	2780	631	142	89	54
6	Friuli- Venezia Giulia	1229	546	131	107	19	11
7	Lazio	5870	3160	279	47	39	24
8	Liguria	1592	890	54	34	8	5
9	Lombardy	9973	4595	1012	101	143	86
10	Marche	1553	764	196	126	28	17
11	Molise	315	124	8	27	1	1
12	Piedmont	4437	2004	382	86	54	32
13	Apulia	4090	1928	133	32	19	11
14	Sardinia	1664	742	194	116	27	16
15	Sicily	5095	2391	167	33	24	14
16	Tuscany	3751	2234	370	99	52	31
17	Trentino- Alto Adige	1052	495	122	116	17	10
18	Umbria	897	470	88	98	12	7
19	Valle D'Aosta	129	73	5	42	1	0
20	Veneto	4927	2213	662	134	94	56
	Italy	60783	29595	5224	86	739	444

Table 2. Italian potential biogas and biomethane production based on a theoretical OFMSW mass in 2013, that should be 37% of MSW (ISPRA, 2015)

N.	Region	Inhabitants (10 ³)	MSW (10 ³ t)	OFMSW (10 ³ t)	OFMSW per inhabitant (kg/person year)	Potential biogas production (10 ⁶ m ³ /year)	Potential biomethane production (10 ⁶ m ³ /year)
1	Abruzzi	1334	600	222	166	31	19
2	Basilicata	578	207	77	133	11	7
3	Calabria	1981	833	308	156	44	26
4	Campania	5870	2545	942	160	133	80
5	Emilia- Romagna	4446	2780	1029	231	146	87
6	Friuli- Venezia Giulia	1229	546	202	164	29	17
7	Lazio	5870	3160	1169	199	166	99
8	Liguria	1592	890	329	207	47	28
9	Lombardy	9973	4595	1700	170	241	144
10	Marche	1553	764	283	182	40	24
11	Molise	315	124	46	146	6	4
12	Piedmont	4437	2004	741	167	105	63
13	Apulia	4090	1928	713	174	101	61
14	Sardinia	1664	742	275	165	39	23
15	Sicily	5095	2391	885	174	125	75
16	Tuscany	3751	2234	827	220	117	70
17	Trentino- Alto Adige	1052	495	183	174	26	16
18	Umbria	897	470	174	194	25	15
19	Valle D'Aosta	129	73	27	209	4	2
20	Veneto	4927	2213	819	166	116	70
	Italy	60783	29595	10950	180	1550	930

Also the difference between the potential biomethane production from the theoretical OFMSW (37% of MSW) and that from the actual OFMSW was computed for each region of Italy (Fig. 1).

The potential biomethane production should be increased by 486 million m³ for the whole Italy, while Sicily resulted the region having the highest possible increase (61 million m³) (Fig. 2).

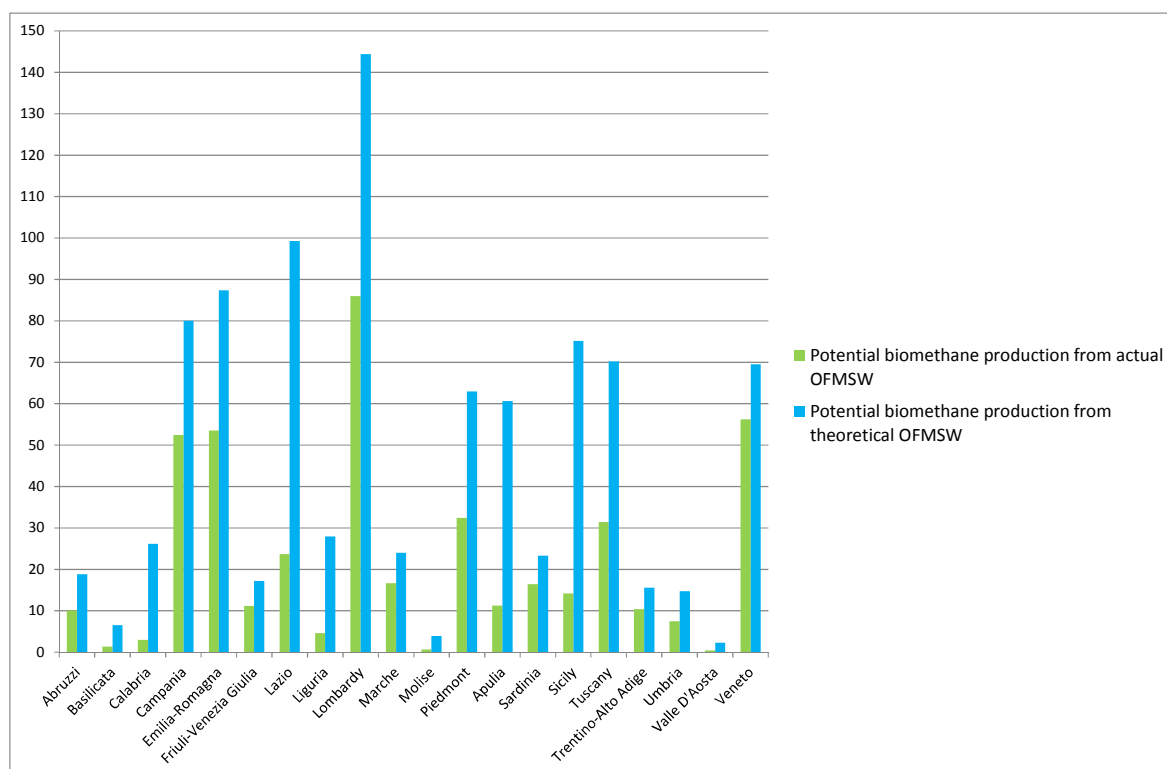


Figure 1. Potential biomethane production based on the actual OFMSW mass in 2013 and that from the theoretical OFMSW mass (37% of MSW) for each region of Italy (10⁶ m³/year)

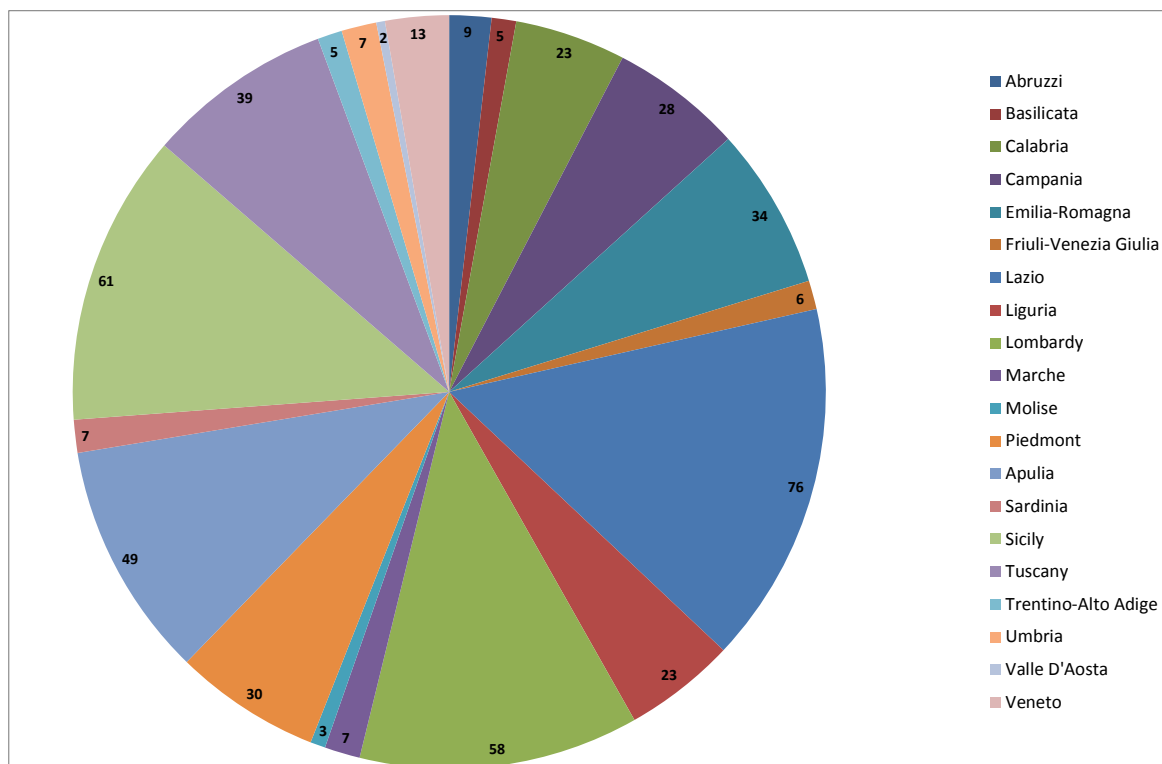


Figure 2. Difference between the potential biomethane production based on the theoretical OFMSW mass (37% of MSW) and that from the actual OFMSW mass in 2013 for each region of Italy ($10^6 \text{ m}^3/\text{year}$)

Conclusions

The results of this work, showing the possibility of highly increasing the Italian potential biogas and biomethane production through the AD process of organic wastes, e.g. OFMSW, must be included in the perspective of achieving the targets of EU policies about waste, energy, environment and climate.

In fact, the EU Directive 2003/55 has authorised the connection to the natural gas grid: it is possible to inject biomethane, that is a refined biogas having a methane concentration higher than 95% and a quality comparable to that of natural gas. In order to produce pipeline quality biomethane starting from the biogas generated through AD process, it is needed to remove water, sulphur compounds, halogenated organic molecules, carbon dioxide, oxygen and metals (Molino et al., 2013).

Among the possible applications of biogas, if it was upgraded into biomethane, this biofuel would replace natural gas and, therefore, allow a reduction of GreenHouse Gas emissions of $200 \text{ g of CO}_2 \text{ kWh}^{-1}$ (5.5 times lower) and the import of fossil fuels from abroad (Marangoni et al., 2013) for transportation and network applications (Molino et al., 2013).

Several authors have shown that the production unit cost of biogas is 8-10 €/cents/ m^3 (depending on the organic matter source), while the upgrading cost is 7-8 €/cents/ m^3 , so that the total cost for producing biomethane compressed into the gas grid at 30 bar pressure is 20-22 €/cents/ m^3 . The Italian market price of natural gas, fixed by the National Authority for the Electrical Energy and Gas Use, is equal to 40 €/cents/ Nm^3 (referred to January 2010) and, therefore, justifies the industrial feasibility of the above process (Molino et al., 2013).

Following the Decree of the 5th December 2013 of the Italian Ministry of Economic Development (2013) about the ways to promote the injection of biomethane into the natural gas grid, this biofuel will play a paramount role in the fuel market in the next five years. Moreover, as a poor energy balance is associated with many first generation liquid biofuels (e.g. rape seed biodiesel) and the public concern towards biofuels displacing food production is increasing, the concept of using biomethane from organic wastes as a biofuel is very attractive (Mata-Alvarez, 2003; Directive 2009/28/EC; Korres et al., 2010).

Furthermore, fossil fuels are limited resources, concentrated in a few geographical areas of the Earth. This generates, for the countries outside these areas, a permanent state of dependency on imported energy. Most European countries are strongly dependent on fossil fuels, imported from regions rich in fossil fuel sources, e.g. Russia and the Middle East. The development and implementation of renewable energy sources, such as biogas from AD, based on national and regional biomass, will increase the security of the national energy supply and reduce the dependency on imported fuels.

Fighting against global warming is one of the main priorities of European energy and environmental policies. The production and use of biogas from AD has the potential to comply, at the same time, with all the three main goals of the EU climate and energy package for 2020: to reduce GreenHouse Gas (GHG, e.g. CO₂) emissions by 20%; to improve energy efficiency by 20%; to generate 20% of energy consumption from renewable energy sources. A major part of renewable energy will be produced from European agriculture and forestry, through biomass conversion into gaseous, liquid and solid biofuels (Comparetti et al., 2013a). In this perspective politicians should promote the valorisation of organic wastes (e.g. OFMSW) through AD process. In fact, whether OFMSW was anaerobically digested, it would highly reduce the amount of this waste that is nowadays aerobically composted or, even worse, landfilled (Comparetti et al., 2013c).

If the Italian towns, that support a high cost for OFMSW transportation to landfills or composting plants and the subsequent treatment, would implement AD, could achieve a high saving. At the same time the environmental benefits for all citizens would be the reduction of GHG emissions, as well as soil and ground water pollution by leachate.

The limitation of implementing the results of this work is “ecomafia”, that is the mafia involved in environmental business and, therefore, controlling the waste management. The “criminal systems” (as defined by the judge Roberto Scarpinato) are complex illegal networks including policy makers, entrepreneurs, professionals and traditional mafia men. Therefore, a cultural change is needed, firstly in citizens and secondly in policy makers, entrepreneurs and professionals, in order to optimise the separate waste collection and the subsequent recycling, as well as valorise OFMSW through biogas and digestate production (Comparetti et al., 2014).

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Analysis of the braking performance of counterbalanced forklift truck at varying of the tread wear

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Abstract

The market provides tires for counterbalance forklift trucks with different kinds and depths of tread: the level of tire wear opens issues about the related safety level, in particular during braking. This research aims at verifying the effect of rubber solid tire wear on counterbalance forklift truck braking performance to verify braking performance compliance with regulations as well as standard requirements.

One counterbalance forklift truck was equipped with three different sets of rubber tires characterized by different wear levels provided that within the legal limits (new, wear, almost completely wear) evaluating its braking performance according to ISO 6292/2009 standard. Experimental activity was carried out driving the counterbalance forklift truck in two ballast conditions on three different kinds of surfaces: dry asphalt (according to ISO 6292/2009), wet asphalt and one low friction flooded surface. Different loads were applied on the brake pedal to evaluate the related braking behaviors (stopping distance and deceleration). Acquired data underwent statistical processing by means of Minitab 17.0 statistical package.

According to preliminary investigations, the kind of surface and the ballast the counterbalance forklift truck is subjected to, turn out to be the factors significantly affecting the braking performance while tire wear level does not seem to have a significant role. Further studies are nevertheless required to deepen the knowledge about the interaction between tire wear level and surface/ballast.

Keywords: Safety, Slick Rubber Tire, Wheel Locking.

Introduction

Different kinds of tires for counterbalance forklift trucks can be found on the market: all of them can be basically divided into pneumatic and solid ones (these furtherly divisible in other subcategories). The guidelines of the Italian National Institute for Insurance against work accidents (INAIL, the public non-profit board safeguarding workers against physical injuries and occupational diseases), specifies which controls have to be carried out for the different kind of tires (pneumatic, superelastic and cushion) to confirm the importance of the influence of tires regarding safety. In particular, resilient solid tires are characterized by a depth of tread that can be completely smooth at the end of its life: the technical indicator of complete wear tire is called 60J and is not related with the depth of the tread. The tire wear level opens issues about the related braking performance in particular on wet surface.

This research aims at verifying the effect of rubber solid tire wear on the braking performance of counterbalance forklift truck to check the braking performance compliance with regulatory and standard requirements.

Test were conducted to evaluate the influence of three solid tire different wear levels (0%, 50%, 95%), all of them within the law limits, with braking tests.

Material and methods

The standard we referred to is the ISO 6292:2008, titled “*Powered industrial trucks and tractors -- Brake performance and component strength*”, that specifies the performance and test methods for brake systems fitted to powered industrial trucks of all capacities, industrial tractors with rated capacities up to and including 20 000 N drawbar pull, burden carriers and industrial trucks handling freight containers. Three different sets of resilient solid tires, whose main technical and geometric specifications are reported in tab. 1, were adopted.

Table 1. Main characteristics of the tested tires.

Measure (ETRTO standard)	Rolling circumference	Test code
7.00-12	2053/2053	T_0
	1913/1914	T_50
	1744/1747	T_95
6.00-9	1639/1639	T_0
	1524/1524	T_50
	1362/1374	T_95

The tested tires have been fitted on the counterbalance forklift truck shown in fig. 1 whose main characteristics and the test conditions are reported in tab. 2

Table 2. Main characteristics of the tested truck.

Type	Internal combustion
Nominal load (kg)	2500
Mass without ballast(kg)	4070
front (kg)	1765
rear (kg)	2305
Mass with ballast* (kg)	5270
front (kg)	3695
rear (kg)	1575

*the chosen ballast was 1.200 kg



Figure 1. The forklift truck during one of the tests carried out on asphalt with the T_95 set of tires.

Braking tests were carried out on asphalt and concrete, in both wet and dry conditions (fig. 2), and on a low friction surface. To this last purpose, one sheet of polyvinyl chloride (PVC) constantly kept wet was adopted (fig. 3) choosing the ballast and the pedal load so that the testing conditions could be as close as possible to those adopted for asphalt and concrete surfaces. Therefore, the complete set of surfaces and conditions turned out to be the following:

- Asphalt dry;
- Asphalt wet;
- Concrete dry;
- Concrete wet;
- PVC wet.



Figure 2. The tested forklift truck during one test on wet asphalt with the T_0 set of tire.

The friction between the tires and the PVC sheet (fig. 3) has been assessed measuring the force required to pull the forklift truck both up to incipient tire locking and locked tires.

These values, dimensionless, resulted respectively of 0.15 ± 0.01 e 0.21 ± 0.02 .



Figure 3. Example of the equipment layout of the test on PVC.

Despite the followed methodology is based on ISO 6292/2008 requirements, given the experimental aim of the test (as a matter of fact, the different tread wear and the wet surface are not cited in the standard), further test settings, described in detail in the paper, were required. The term “wet surface” means that during the braking performance assessment, the surface was constantly kept wet by the presence of a water film (fig. 4).



Figure 4. Example of wet surface condition.

The ISO standard requires the maximum speed set at maximum the forklift truck is capable of. Nevertheless, the different tires tread wear gave rise to different rolling circumferences determining different maximum forward speeds at varying of the fitted set of tires. Therefore, to compare the results, it was necessary to adopt a common value of maximum forward speed. This was achieved adopting, at the beginning of the brake test, the lowest of the maximum forward speed (15 km h⁻¹) corresponding to that of the T_95 set.

The chosen ballast was a mass as to prevent the rear tires from losing the contact of with the surface during the braking by placing the forks as low as possible without touching the surface also during the test.

The test conditions and the adopted test codes are reported in detail as follows:

- Forward speed at starting braking: 15 km/h;
- Maximum force on the brake pedal:
 - Runs on asphalt and concrete: max 45 kg;
 - Runs on PVC: 45 kg or tire locking;
- Surfaces:
 - Asphalt:
 - dry: AD
 - wet: AW
 - Concrete:
 - dry: CD
 - wet: CW
 - PVC:
 - wet: PW
- Ballast:
 - not ballast: N
 - ballasted with 1.200 kg: Z
- Repetitions:
 - asphalt and concrete: at least 5;
 - PVC: at least 5 and pedal load/deceleration correlation;
- Direction: only with forward speed (not in rearward);
- Starting measurement: at reaching of the 0.3 kg defined load on pedal brake.

The measurements of the mass of the forklift truck was carried out by means of a weighing platform of 20 tons. The forward speed has been measured adopting a fifth wheel. The details of the used instruments are reported in table 3.

Table 3. Instruments and materials adopted

Instrumentation	Make/model	Measurement
Weighing machine	Bulgari 20 t	Mass
Fifth wheel	Peiseler	Forward speed Distance
Load cell	Leane 2361 e Leane CPF Disp	Pedal load

Acquired data were processed by means of analysis of variance (ANOVA) followed by the means multiple comparisons (Tukey’s test) to point out possible significant differences between test settings ($p < 0.05$).

Results

Tables 4 and 5 display the results of the braking tests carried out on asphalt and concrete surfaces. With reference to these two surfaces, the analysis of variance followed by multiple comparisons of means did not show the three tire sets (T_0, T_50 and T_95) to significantly affect the braking performance ($p = 0.68$). On the contrary, the “surface” factor showed to be significant ($p < 0.05$) and the mean deceleration on asphalt (4.08 m s⁻²) is significantly different from the one on concrete (3.95 m s⁻²). In the same way the results obtained at varying of surface condition (dry or wet) were found to be significantly different with the mean deceleration value of 4.23 m s⁻² in dry conditions and 3.78 m s⁻² in case of wet surface.

As far as ballast is considered, its presence turned out to be significant for deceleration values: as a matter of fact deceleration values of 4.26 m s⁻² and 3.78 m s⁻² respectively in case of ballast and non-ballast condition. Table 6 reports the homogeneous groups of means resulting from ANOVA and Tukey’s test.

Table 4. The results on the asphalt surface (data are expressed as arithmetical mean of the repetitions in each condition)

Surface code	Tire Set	Ballast code	Forward speed (km/h)	Pedal load (kg)	Braking distance (m)	Deceleration (m/s ²)
AW	T_0	Z	15.1	41.2	2.16	4.05
		N	15.1	35.8	2.38	3.72
	T_50	Z	15.2	39.1	2	4.33
		N	15.1	40.2	2.64	3.32
	T_95	Z	15.1	37.4	1.96	4.63
		N	15.0	37.2	2.50	3.44
AD	T_0	Z	15.1	41.2	2.20	4.10
		N	15.1	38.1	2.16	4.00
	T_50	Z	15	40.2	1.76	4.95
		N	15	39.7	2.02	4.24
	T_95	Z	15.1	38.8	2.00	4.40
		N	15.0	36.1	2.20	3.94

Table 5. The results on the concrete surface (data are expressed as arithmetical mean of the repetitions in each condition)

Surface code	Tire Set	Ballast code	Forward speed (km/h)	Pedal load (kg)	Braking distance (m)	Deceleration (m/s ²)
CW	T_0	Z	15.1	39	2.2	4
		N	15	37.7	2.3	3.81
	T_50	Z	15	37.7	2.26	3.87
		N	14.9	40.8	2.62	3.31
	T_95	Z	15	39.9	2.16	3.97
		N	14.9	42	2.58	3.3
CD	T_0	Z	14.9	39.9	2.02	4.22
		N	15.1	39	2.14	4.12
	T_50	Z	15	38.3	2.02	4.35
		N	15	39.8	2.08	4.16
	T_95	Z	14.9	40.4	1.94	4.37
		N	14.9	40.1	2.1	4.04

Table 6. Results of the ANOVA of the braking test on asphalt and concrete

Set	Test conditions							
	AD_N	AD_Z	AW_N	AW_Z	CD_N	CD_Z	CW_N	CW_Z
T_95	b	b	b	a			b	
T_50	a	a	b	b	ns	ns	b	ns
T_0	b	b	a	b			a	

The “a” indicates higher values of deceleration

As far as braking tests on PVC wet surface are concerned, table 7 and figure 5 report the deceleration (m s⁻²) and braking distance (m) average values.

As expected, increasing the pedal load leads to increasing values of deceleration and decreasing values of braking distance and, in the framework of the pedal loads reported in table 6, only some trends can be pointed out so that further investigations should be carried out.

With reference to deceleration and braking distance values obtained with pedal loads resulting in tire locking (higher than 20 kg and lower than 45 kg), the ANOVA followed by Tukey’s test (table 8) showed that T_0 set of tires significantly affects the lift fork truck braking performance resulting to be the one with the higher deceleration (1.42 ± 0.068 m s⁻²) and the lower braking distance (6.17 m s⁻²). The braking performance of the other tire sets resulted to be each other significantly different only with reference to deceleration while braking distance did not show any homogeneous group.

Table 7. The results on wet PVC surface till brake locking

Surface	Set	Ballast	Forward speed (km/h)	Pedal load (kg)	Braking distance (m)	Deceleration (m/s ²)
PW	T_0	Z	14.8	14.3	11.9	0.71
		Z	14.9	15.6	10.5	0.81
		Z	15	18.8	8.3	1.04
		Z	15	20.6	6.4	1.36
		Z	14.9	23.4	5.6	1.54
		Z	15	14.3	11.9	0.76
	T_50	Z	15.1	16.5	8.4	1.05
		Z	15.2	20.2	6.6	1.34
		Z	15.1	23.4	6.9	1.27
		Z	14.9	25.3	5.8	1.49
		Z	15	13.8	10.5	0.83
		Z	14.9	16.6	7.7	1.11
	T_95	Z	14.9	19.7	6.6	1.3
		Z	14.7	21.7	6.8	1.22
		Z	14.9	24	6.7	1.28

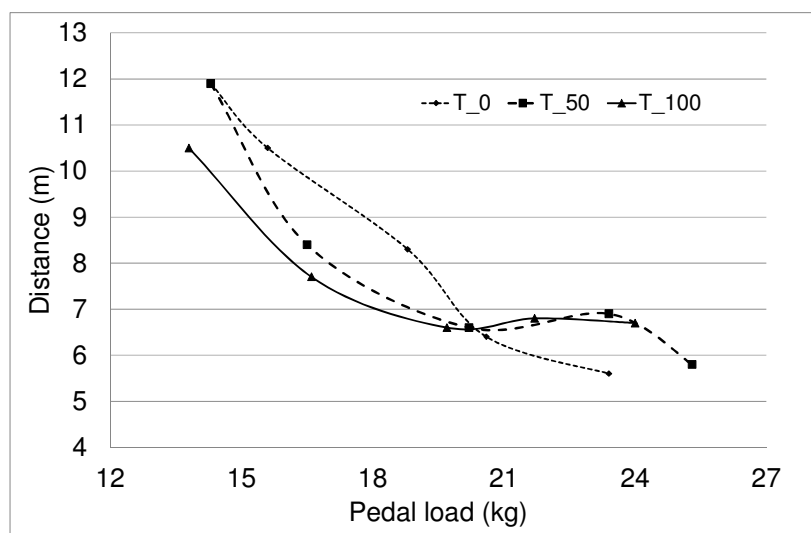


Figure 5. Trend of the correlation pedal load/braking distance on the wet PVC.

Table 8. Tukey’s test and mean values of the braking distance and deceleration obtained on PVC with pedal load between 20 and 45 kg*.

Set	Deceleration (m s ⁻²)		Distance (m)	
	Mean value and group.	Standard Deviaton	Mean value	Standard Deviation
T_95	1.18 c	0.079	7.23 a	0.485
T_50	1.30 b	0.077	6.83 a	0.433
T_0	1.42 a	0.068	6.17 b	0.315

* Testing conditions (ballast and pedal load) as close as possible to those adopted for asphalt and concrete surfaces.

Conclusions

The forklift truck doesn’t present significant differences of braking performance at varying of the set of tires on concrete and asphalt test.

The set wear at 95% (T_95) presents, meanly, a lower deceleration of the new tire if the truck is not ballasted but higher if ballasted.

The difference of deceleration between the set new and the wear at 95% on wet PVC surface resulted significant with a difference between mean values (1.18 and 1.42 m s⁻²) of 0.24 m s⁻² (1.06 m).

Acknowledgements

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Summary of U.S. Agricultural Confined Space-Related Injuries and Fatalities and Comparable International Findings

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Abstract

Purdue University’s Agricultural Safety and Health Program has been documenting injuries and fatalities associated with agricultural confined spaces for over 30 years. To date, nearly 1,800 U.S. incidents/cases have been documented and findings entered into a database. In addition, cases outside the U.S. have been documented, but not included in summary data reported to date. Findings from the U.S. cases have been summarized and reported on an annual basis for the past decade. These findings have been used to promote enhanced safety measures designed to reduce the severity and frequency of agricultural confined space-related incidents. This presentation summarizes all documented incidents including those identified outside the U.S. It is believed, based upon the frequency of non-U.S. incidents, that the problem of worker injuries and fatalities while working inside agricultural confined spaces is an international safety issue. This is especially true for incidents involving the transport, storage, and processing of agricultural grains.

Findings regarding causative factors such as type of grain and structure, worker characteristics, and the role of out-of-condition grain on increased risk of entrapment will be presented. Recommended preventative measures will be discussed.

Keywords: Grain Entrapment, Agricultural Confined Spaces, Grain Engulfment, Toxic Environments

Introduction²

As part of an effort to gain a better understanding of U.S. grain-related entrapments³ and engulfments, Purdue’s Agricultural Safety and Health Program (PUASHP) has published, over the last decade, an annual summary of these incidents⁴ (www.agconfinedspaces.org). These summaries are based on data gathered, documented and entered into Purdue’s Agricultural Confined Space Incident Database (PACSID). With support from the U.S. Department of Labor’s Susan Harwood Training Program, over the past four years, the surveillance effort was expanded to include not only incidents of entrapments in grain, but also asphyxiations, entanglements, falls, fires and electrocutions in and around all forms of

²Partial support for this material was provided under grant number SH24885SH3 from the Occupational Safety and Health Administration, U.S. Department of Labor. It does not necessarily reflect the views or policies of the U.S. Department of Labor, nor does mention of trade names, commercial products, or organizations imply endorsements by the U.S. Government.

³ Flowing grain entrapments include both fatal engulfments and partial entrapments that require assistance in order for the victim to be extricated.

⁴ An incident may involve multiple victims that are recorded in the database as individual cases.

agricultural confined spaces.⁵ This annual summary, based upon 2014 incidents continues to reflect this expanded effort and hopefully adds additional light on a problem that poses significant risk to agricultural workers. Though not aggressively investigated, a brief summary of incidents documented outside the U.S. is included.

As the result of using the broader definition for agricultural confined spaces to identify cases of interest, no fewer than 70 U.S. cases were documented in 2014. Of these, approximately 54% were directly related to grain entrapments. To ensure continuity of the data record involving entrapments in grain and other free flowing agricultural material, and due to the high percentage of past fatal cases involving grain entrapment, special attention continues to be given to these incidents.

In addition to the cases documented in 2014, approximately 50 cases that occurred in previous years were added to the database due to ongoing discovery efforts. Also, 11 cases were removed from the database as they, upon further investigation, no longer met the criteria for having occurred in an agricultural confined space, or occurred outside the U.S. The total number of U.S. cases documented to date and entered in the PACSID is nearly 1,800. The identification of additional cases can be attributed to the increased surveillance efforts allowed by the support from the U.S. Department of Labor as well as increased public awareness of the problem leading to greater media exposure and voluntary reporting.

As noted in past summaries, the data presented do not account for all incidents involving agricultural confined spaces. There continues to be no comprehensive or mandatory incident/injury reporting systems for most of agriculture, and there is reluctance on the part of some victims and employers to report non-fatal incidents, even where extrication was required, and therefore no public record is available. Based upon prior research, it is estimated that the documented annual cases represent approximately 70% of the total cases that actually occur annually in the Corn Belt where most U.S. Grain is produced.

2014 Summary of All Agricultural-Confined Space-Related Cases with Comparisons to Previous Years

In 2014, there were no fewer than 38 U.S. grain entrapment cases, 12 falls, 8 equipment entanglements (including augers), 9 fire related injuries and 3 asphyxiations that were identified as occurring in an agricultural confined space (Figure 1). Grain entrapments accounted for 54% of the documented cases. For incident types with more than one case, asphyxiations due to toxic environments, constituted the most dangerous with a reported 67% fatality rate, while grain entrapments ranked fourth with a 45% fatality rate. Again, it is believed that most confined space incidents are under-reported especially those resulting in non-fatal grain entrapment and involving being overcome by toxic gases such as found in manure storage facilities.

The 70 confined space cases represent a 4% increase in number of cases from 2013 when 67 cases were recorded. The previous three years (2010, and 2011, 2012) experienced 100, 64 and 46 documented cases respectively (Figure 2). The five-year average continues at a relatively high level of 69.4, slightly below the peak of 74.8 in 2011. Since 2002, the five-year average has increased steadily from 36.8 cases per year to an average of 52.6 cases per year in 2008, 61.2 in 2009, and 70.8 in 2010, and peaking in 2011 with 74.8 cases.

⁵ The definition used to identify an agricultural confined space in this study is: Any space found in an agricultural workplace that was not designed or intended as a regular workstation, has limited or restricted means of entry or exit, and has associated with it potential physical and/or toxic hazards to workers who intentionally or unintentionally enter the space.

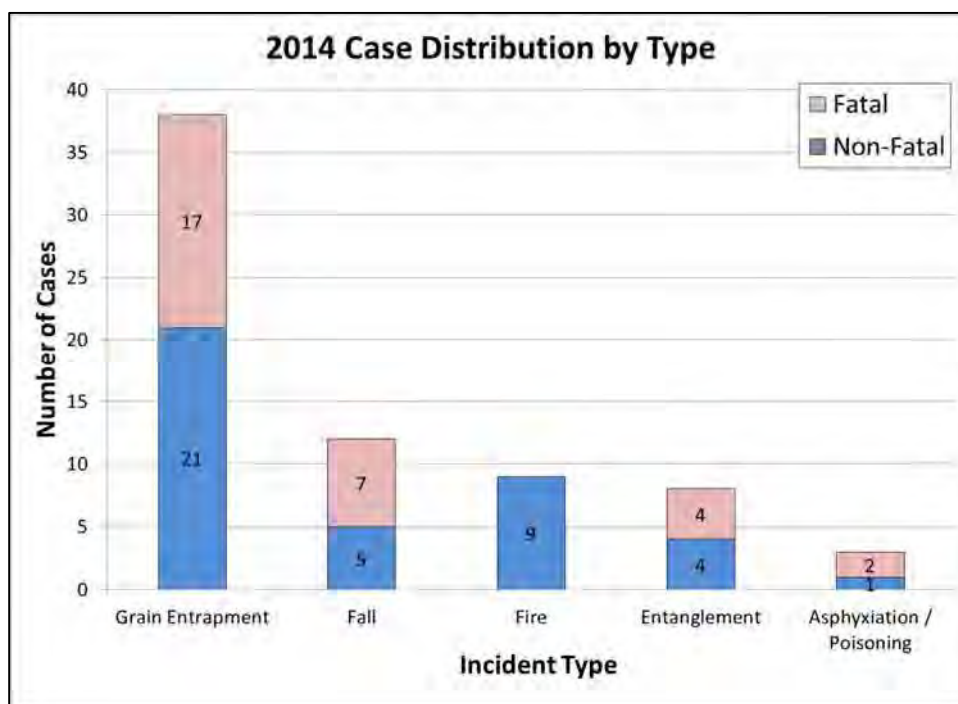


Figure 1. Distribution of 2014 agricultural confined space-related cases by type of incident.

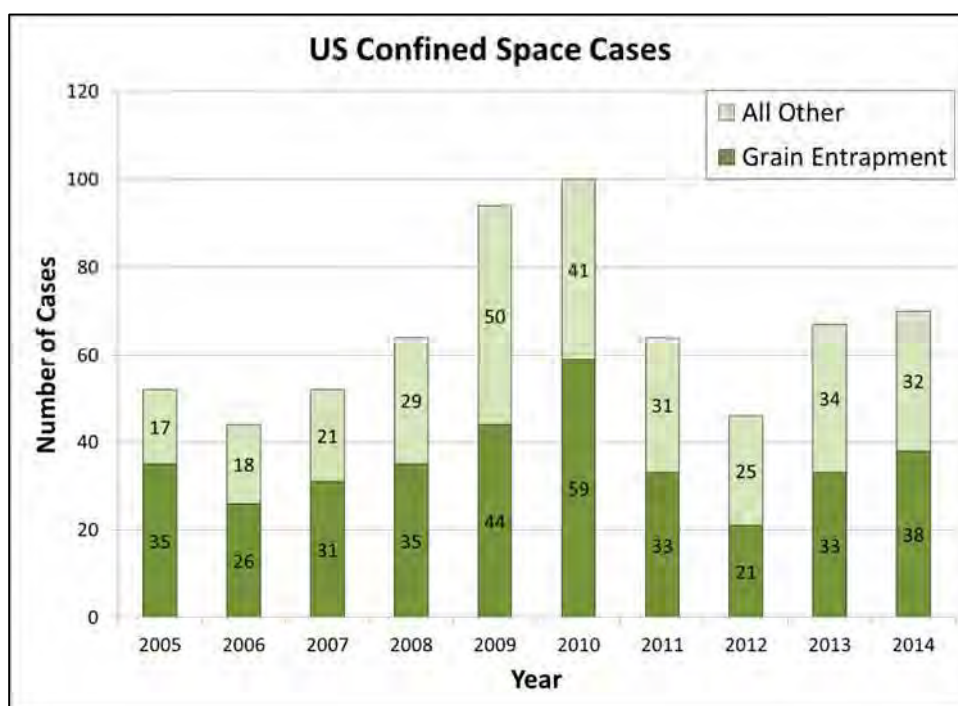


Figure 2. Number of annual confined space cases recorded between 2005 and 2014.

In 2014, the states with the most documented confined space cases, of all types, including fatal and non-fatal, were Minnesota (9) and Ohio (9). Seven of Ohio cases involved one incident in which a fire injured seven workers while attempting to extinguish a fire inside a grain storage structure. There were five cases each for Indiana, Nebraska, Illinois, and

Wisconsin. There were four cases each for Michigan, Iowa and Pennsylvania. Overall, incidents were documented in 20 states in 2014, three states less than 2013. Figure 3 provides a geographic distribution of all documented cases in the PACSID, where the location was known, and the sites, where known, for 2014. It should be noted that the high number of cases identified in Indiana reflects a more aggressive surveillance effort historically.

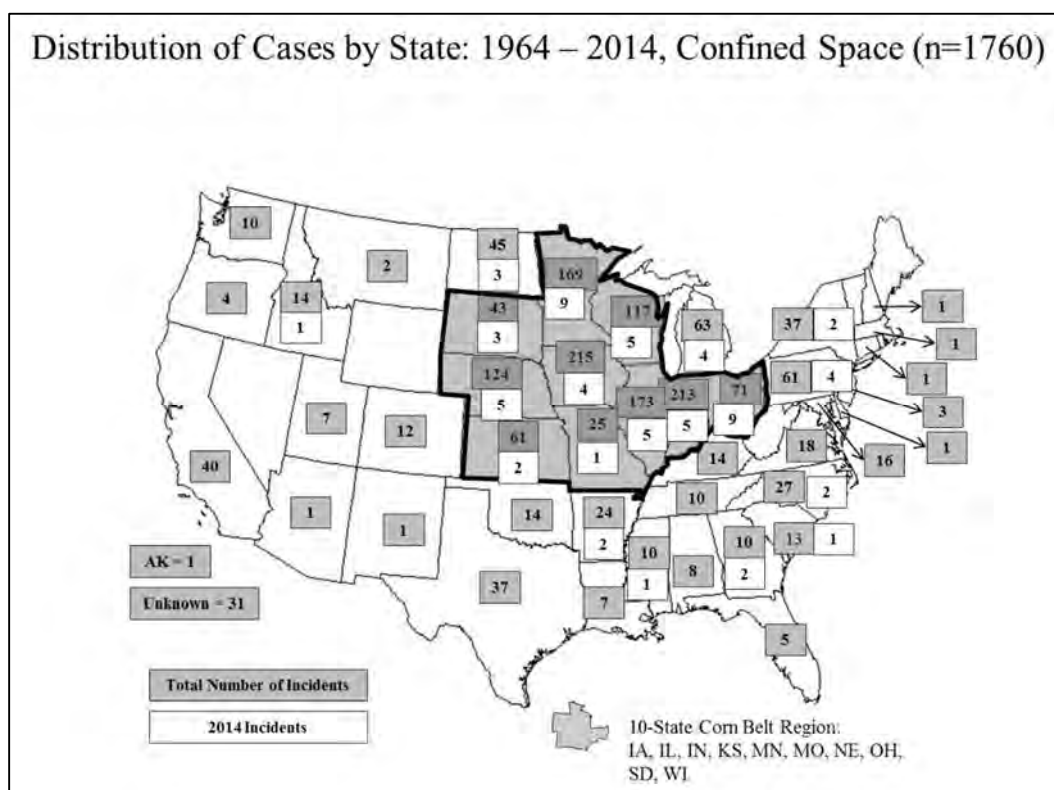


Figure 3. Geographic distribution of confined space cases for 2014 and previous years.

There was only one case in 2014 involving a female. Also, there were six cases involving a child or youth under the age of 20, as shown in Figure 4. Overall, a specific age was known for 46 of the 70 victims in 2014, with the oldest victim being 81, and the youngest 5 years old. The average age was 45 years old, and the median age 51.5 (Figure 4), which is significantly lower than the current average age of 58 for U.S. farmers. As can be noted, a large number of the cases documented did not include a specific age of the victim.

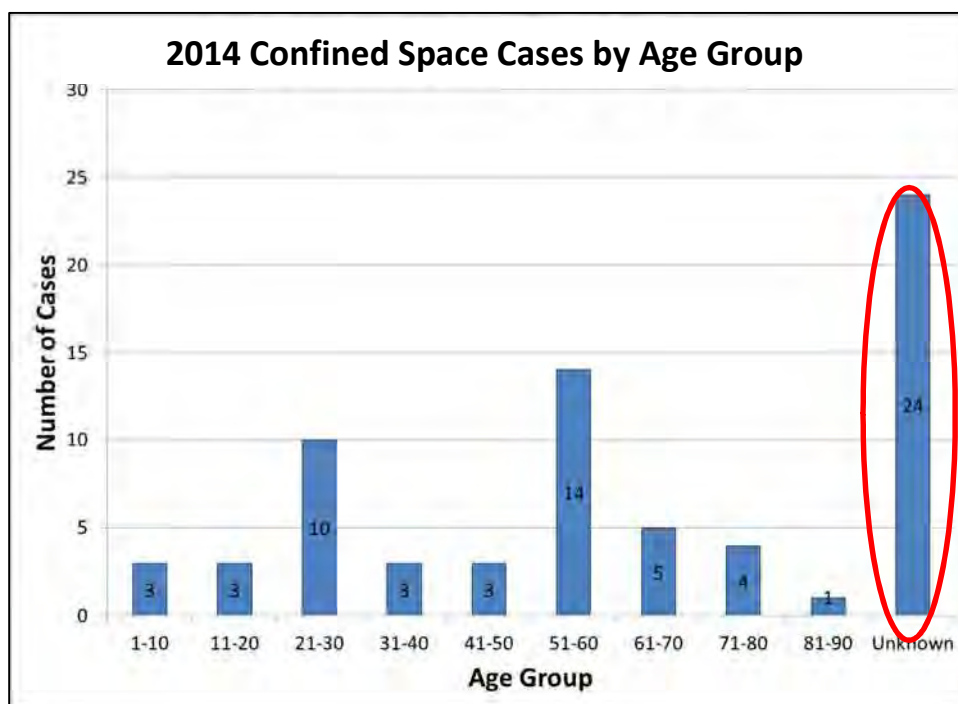


Figure 4. Age distribution of 2014 agricultural confined space victims by number of cases recorded.

2014 Summary of Grain Entrapments with Comparisons to Previous Years

The 38 grain entrapment cases in 2014 represent a 15% increase in entrapments from 2013 when 33 entrapments were recorded. The previous three years (2010, and 2011, 2012) experienced 59, and 32 and 21 documented cases respectively. The five-year average continues at a relatively high level of 36.8, below the peak of 40.4 in 2011 (Figure 5). In 2014, the state with the most documented grain entrapments, fatal and non-fatal, was Minnesota (6) (Figure 6). There were four cases each for Indiana and Iowa, and three cases each for North Dakota, Wisconsin, Nebraska, South Dakota, and Illinois. Overall, entrapments were documented in 16 states in 2014. The majority of grain entrapment cases occurred in the Midwest (87%), in the region known as the Corn Belt in contrast with 2013 in which only 61% of the cases occurred in the Midwest. Figure 5 provides a geographic distribution of all documented grain entrapment cases contained in the PACSID where the location was known.

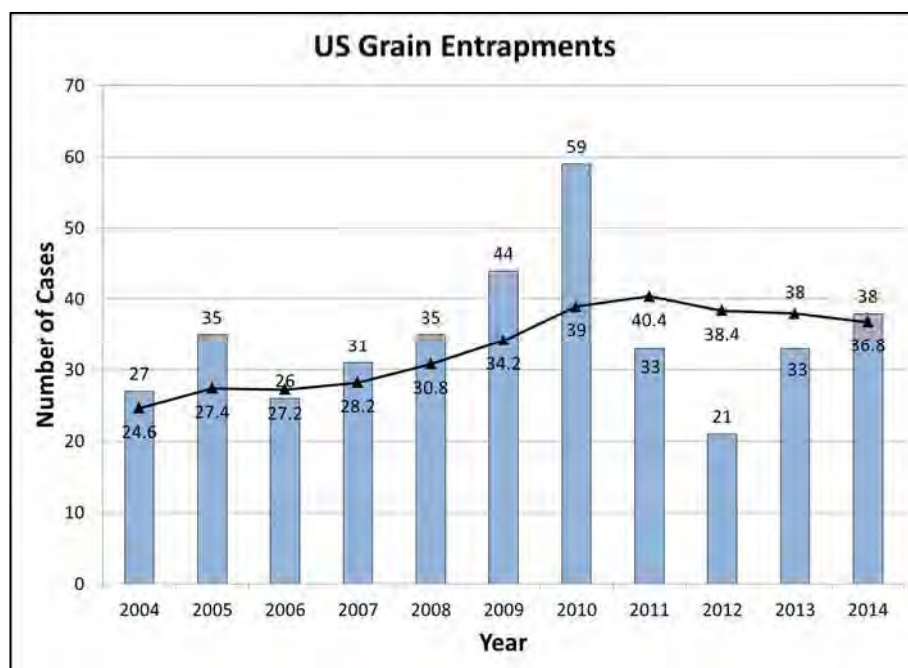


Figure 5. Number of annual grain entrapment cases recorded between 2004 and 2014.

Distribution of Cases by State: 1964 – 2014, Grain Entrapments (n=1096)

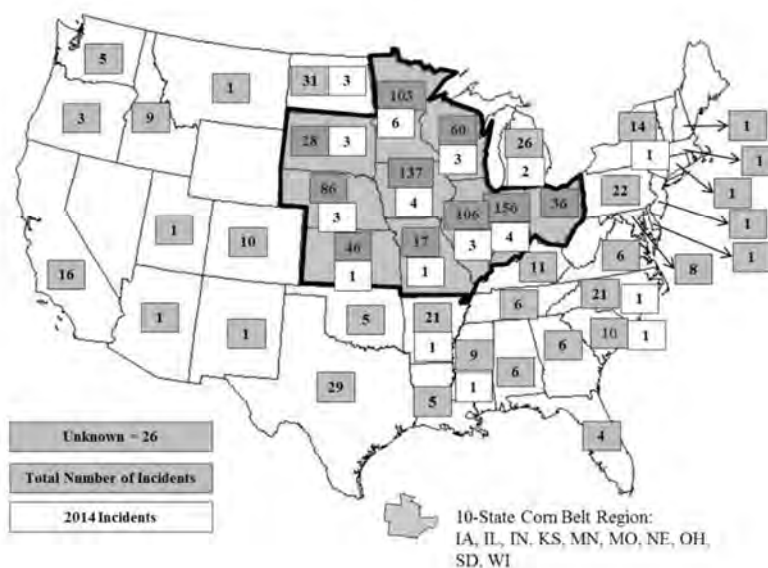


Figure 6. Geographic distribution of grain entrapment cases for 2014 and previous years.

In 2014, there were 36 cases where the exemption status⁶ of the facility with respect to Federal Occupational Safety and Health Administration (OSHA) regulations was known. Of those, 31 (82%) occurred on farms or other locations currently exempt from the OSHA Grain Handling Facilities Standards (29 CFR 1910.272), with the balance of 5 (13%) taking place at non-exempt commercial grain facilities. This is in strong contrast to 2013 and 2012 when 70% and 35% of all cases occurred on exempt farms. It is important to note that there were only 2 unknown cases this year and it is believed that the majority of the unknown cases, based on historical data, have OSHA exempt status.

All documented victims were male except for one case. Also, there were 4 documented cases involving a youth under the age of 20 in contrast to 2013 in which there were no child/young adult cases (Figure 7). Overall, a specific age was known for 26 of the 38 victims in 2013, with the oldest victim being 81, and the youngest 8 years old. The average age was 49 years old, and the median age 53. In contrast to previous years, three of the grain entrapments occurred in grain transport vehicles. The last time a grain entrapment in a grain transport vehicle was documented was in 2011.

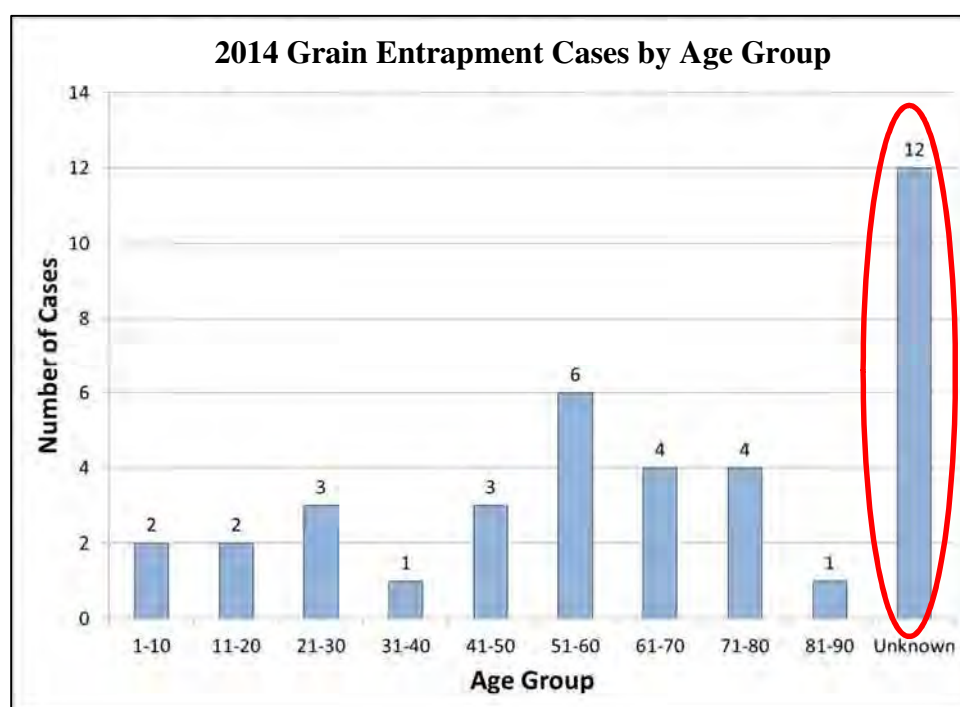


Figure 7. Age distribution of 2014 grain entrapment victims by number of cases recorded.

During 2014, the primary medium, or type of grain, of entrapment, when identified, was corn (19 cases, 50%). Soybeans were the second most common grain with four cases (11%). Unlike previous years the ratio of fatal to non-fatal cases actually rose to 45% in comparison to last year's 39%. This number is still relatively low in comparison to 1964-2008, during which 73% of documented entrapments resulted in a fatality. As in past years, it should be noted that this summary does not reflect all grain-related entrapments, fatal or non-fatal that have occurred. Currently over two-thirds of grain storage capacity in the U.S. is

⁶ Under the current provisions of the two OSHA workplace safety and health standards most relevant to agricultural confined spaces, most agricultural worksites, including most farms, feedlots, and certain seed processing operations are exempt from compliance.

found on farms that are exempt from the current OSHA injury reporting requirement standards.

Summary of Documented Falls in and Around Agricultural Confined Spaces

Falls in and around U.S. agricultural confined spaces represent the third largest group of confined space-related cases after grain entrapments with a total of 180 cases documented to date. However, documented cases for falls have only been continuously recorded since 1990 (177 cases recorded; 13% of all cases). When comparing other categories over the same timeframe, falls are the second highest injury type after grain entrapments. It is believed that the majority of non-fatal falls involving agricultural confined spaces go unreported (Figure 8).

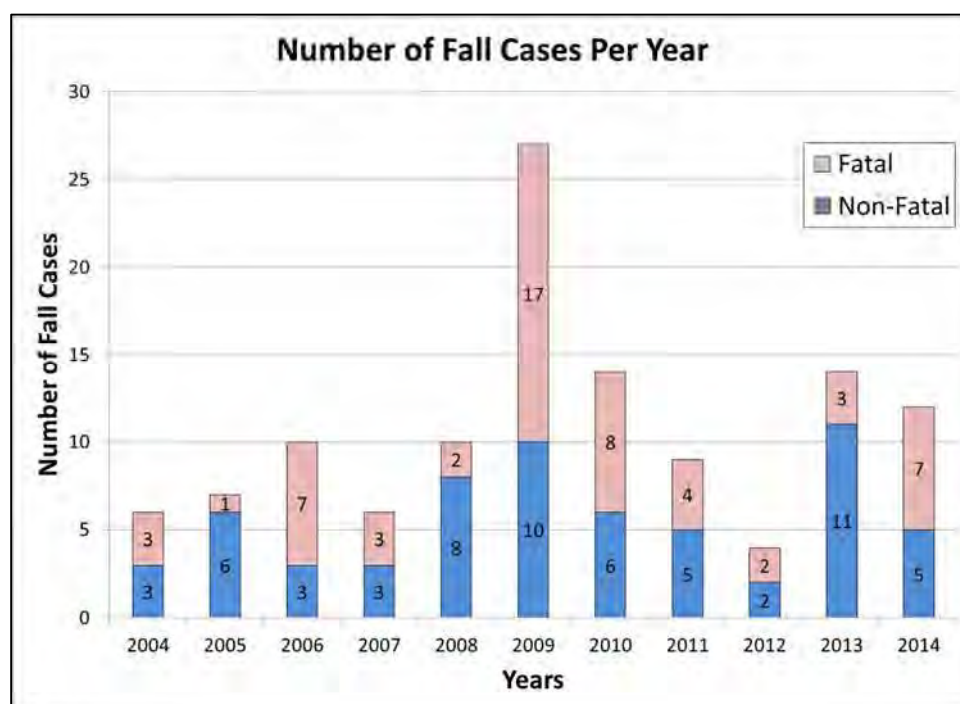


Figure 8. Number of annual fall cases recorded between 2004 and 2014.

Incidents Outside the U.S.

A review of the literature did not identify any ongoing surveillance efforts outside the U.S. to document deaths or injuries in agricultural confined spaces. The fact that numerous countries have published safety resources related to the hazards of these work spaces provides an indication that this is an international problem. In addition, there have been a sufficient number of international cases identify by the Purdue effort to confirm that there are many similarities between the cases documented in the U.S. and the rest of the world.

A review of published farm injury data from several of the Canadian provinces found incidents involving several types of agricultural confined spaces with a prevalence of cases involving grain handling and manure storage. For example, a recent case in 2015 in Nova Scotia involved a 20 year old worker buried to his chin in a corn bin. He was successfully rescued by emergency personnel after several hours of being entrapped.

A case was documented in Bagworth, Leicester, England in which an 8 year old boy was engulfed and suffocated in a corn bin. Another case in Sussex, England involved a 13

year old male entrapped in a bin of Linseed. He was successfully rescued by a tactical rescue team using ropes to lower rescuers to the surface of the grain and attaching a safety harness to the boy. In Brookton, England an 18 year old male farm family member suffocated while attempting to remove corn from a grain bin.

Several cases were documented in Australia, including a case in 2013 in which a total of 10 people, including farm workers, police officers, and paramedics, who were overcome in a farm silo containing fermented corn syrup. These first responders were attempting to rescue a farmer who had become overcome by the toxic environment while working in the silo. There were no fatalities, but the number of first responders injured during the rescue was unusual.

In 2013, four employees at a grain facility in Brazil suffocated in a bin of soybeans while attempting to break up crusted grain. The unloading system was apparently operating while the workers were in the bin.

Verbal accounts of incidents have also been received from literally around the world including Ireland, Finland, Sweden, Poland, China, Argentina, and Mexico. Since documentation from original or verifiable sources was not possible these cases are not included in the PACSID.

The evidence is clear that workers, worldwide, are dying or being injured on a regular basis while working in or around agricultural confined spaces, and during efforts to rescue the primary victim.

New Website

As part of the plan of work for the U.S. Department of Labor’s Susan Harwood Grant, a new website on agricultural confined spaces has been developed and is currently accessible (www.agconfinedspaces.org). This website is intended to be a resource for those conducting safety and health training in the area of agricultural confined spaces with a special focus on grain storage handling, and processing. Training resources are provided that are relevant to farm operators, youth and beginning workers, current workers in the commercial grain industry, and emergency first responders. The site includes an extensive bibliography of resources, frequently asked questions, and related links.

For additional information on this report, contact Professor Bill Field at 765-494-1191 or field@purdue.edu. In addition, refer to these sources for more information on this topic:

- www.agconfinedspaces.org
- www.grainsafety.org
- www.grainsafety.us
- www.grainentrapmentprevention.com
- <http://apps.npr.org/buried-in-grain/>

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Determination of bystander exposure to pesticide spray drift: methodology proposal.

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Abstract

The potential spray drift exposure of bystander and residents from orchard pesticide applications is likely to be higher than from boom sprayers, especially in Italy where the close interconnection between urban and rural areas amplify this phenomenon. On request of European Commission the European Food Safety Authority (EFSA) established a working group (WoG) for revising all available data and procedures to perform the operator, worker, resident and bystander pesticide risk assessment (EFSA, 2014). For orchard crops and vines, the most used dataset is Lloyd et al. (1987). The WoG recommended that further data shall be produced to refine the proposed assessment. Besides having limited data available at present there is no standardized method for collecting data on resident and bystander pesticide contamination. The aim of this work was to assess the efficiency of different collectors types and the different test layouts, in order to evaluate the better solution for detecting the pesticide exposure of bystanders during plant protection product (PPP) application and to propose a test methodology that may be combined with the existing ISO22866 standard methodology for arable crop pesticide drift measurement. The proposed methodology has been applied in field experiments undertaken in 2013 and 2014 measuring spray drift deposits on mannequins (coveralls and synthetic filter clothes collectors) and airborne spray drift (Petri dishes, vertical polythene line collectors). The results obtained have underlined a lacking relationship between different type of collectors, underlining the need of an appropriate experimental framework able to define the most suitable collectors type and layout to be used.

Keywords: Pesticide Bystander Exposure, Airborne Spray Drift, Collector Types, Test Methodology.

Introduction

According to ISO22866 -Crop protection equipment e Methods for field measurement of spray drift-, spray drift is defined as “the quantity of plant protection product that is carried out of the sprayed (treated) area by the action of air currents during the application process”. During and immediately after spray application non target receptors including water, plants and animals can be exposed acutely and may therefore face the risk of adverse effects. Thus drift may cause damage to non-target plants, contaminate water courses, result in illegal residues in food and feed commodities and cause adverse human exposure. The potential spray drift exposure of bystanders and residents from tree plantation as vineyards and orchards pesticide applications is likely to be significantly higher than that from boom sprayers applications. In Italy the close interconnection between the urban and rural areas underline the real phenomenon of spray drift bystander acute exposure and contamination in these conditions. For orchard crops and vines, the most used dataset is Lloyd et al. (1987). The European Food Safety Authority (EFSA) established an *ad hoc* working group (WoG) for revising all available data and procedures to perform the operator, worker, resident and

bystander risk assessment, in order to prepare the “Guidance on the assessment of exposure of operators, workers, residents and bystanders in risk assessment for plant protection products (PPP)” (EFSA, 2014). Besides having limited data available at present there is no standardized method for collecting data on resident and bystander pesticide contamination. In order to use the full range of available bystander and airborne spray drift data obtained using different collectors and layout Butler Ellis *et al.* (2014) try to link one collector type to another type. In this way a new methodology must start from the definition of the collector type most suitable between the collectors normally used. Actually for the evaluation of bystander exposure is possible use a standardized shape collectors (eg. Polythene line used in different layout, Petri dishes, filter material of different nature, etc.) or collectors that simulate a human figure (eg. coveralls wear by mannequins or volunteers); few work debate about the comparison and correlation between these two types of collectors. At present, the most used collector types are likely those standardized; this is due to the easier use in field trials, analysis and data management. The aim of this work was to assess the efficiency of different collectors types and the different test layouts, in order to evaluate the better solution for detecting the pesticide exposure of bystanders during PPP application and to propose an appropriate test methodology that may be combined with the existing ISO22866 for arable crop pesticide drift measurement because actually is the only official standard procedure for drift measurement.

Methods

Two field trials were undertaken (24 October 2013 and 24 October 2014) at a vineyard (espalier training system, row spacing 2,5 m and full leaf growth stage) located near DiSAFA facilities in Grugliasco (TO). Tests were made applying a water solution of Tartrazine E102 tracer at a concentration of about 5 g l⁻¹. Four type of collectors were selected from those normally used for spray drift measurement as defined in Table 1. The first field trial was aimed to study the bystander potential dermal exposure comparing the efficiency of synthetic filter (CAMFIL) and coveralls (TYVEK®) collectors; in this case collectors were placed on three adult mannequins (Figure 1 and Table 2) aligned at 1, 2 and 3 meters from the middle of sprayer’s wheel track while spraying the last tree row of the vineyard. The second trial assessed the airborne spray plume drift and compare the recovery efficiency of Petri dishes (70 mm diameter), placed on a vertical support, and vertical polythene line (Figure 2); the collectors were aligned at 5 and 10 meters from the middle of sprayer’s wheel track while spraying the last tree row of the vineyard.

Table 1. Spray drift collector used.

Trials	2013		2014	
Collector	Synthetic filter¹	Coveralls (adult)²	Petri dish³	Vertical Polythene line⁴
Characteristic	10 cm X 20 cm	non defined	diameter 7cm	10.0 m X 1.98 mm
Dimension	0.020 m ² (200.00 cm ²)	≈1.943 m ² (19429.73 cm ²)	0.015 m ² (153.938 cm ²)	0.006 m ² (62.172 cm ²)
Location eight	Placed on the adult mannequins (1.80 m approx) according to the Figure 1	Adult 1.8 m (approx) sectioned according to the Figure 1	Every 0.5m from 0.5 m to 4.0 m according to the Figure 2	On 7 m vertical masts sectioned into 1.0 m pieces according to the Figure 2

¹Synthetic filter - CAMFIL SPA

²Coveralls Tyvek® - DuPont

³Petri dishes - AppenLab

⁴Portex Fine Bore Polythene line - Smiths Medical International Ltd

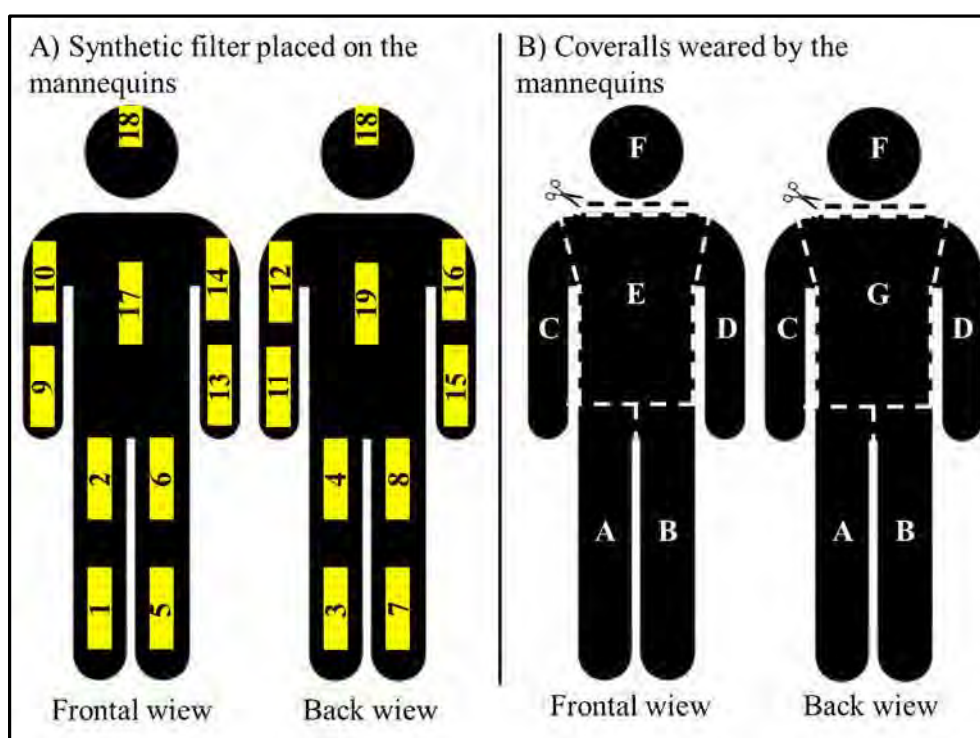


Figure 1. Artificial collectors used in the trials with mannequins: A) synthetic filter placed on the mannequins B) coveralls worn by the mannequins.

Table 2. Correspondance between synthetic filter and coveralls collectors: shared body parts.

Shared body parts	Synthetic filter collectors [ID number]	Coveralls collectors [ID letter]
Leg right	1 - 2 - 3 - 4	A
Leg left	5 - 6 - 7 - 8	B
Arm right	9 - 10 - 11 - 12	C
Arm left	13 - 14 - 15 - 16	D
Chest	17	E
Head	18	F
Back	19	G

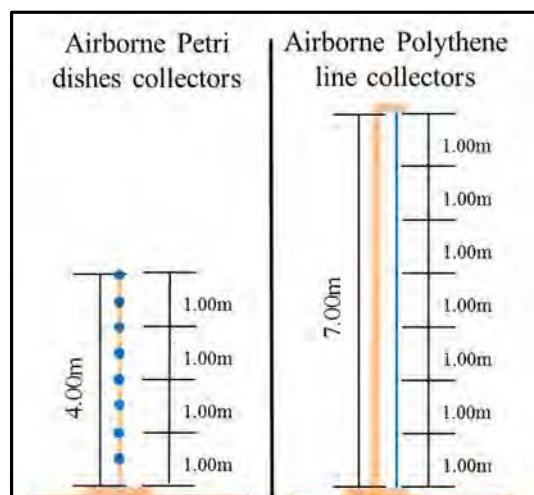


Figure 2. Airborne spray drift collectors: A) Petri dishes B) Polithene line.

Wind speed and direction during the tests were measured and recorded by means of a sonic anemometer (Gill Windsonic), placed at the edge of the downwind area where the collectors were disposed, at a height of 4 m from the ground, linked to a datalogger (Campbell Sci CR200X). Data were acquired and recorded every one second. Air temperature and humidity during the tests were measured by means of a thermo-igrometer (Allemano Testo 400).

Two different axial fan sprayers has been used. The main operative parameters are shown in Table 3.

Table 3. Main operative parameters of the sprayers used in the trials.

Trials		2013	2014
Sprayer		Fede Qi90	Tifone Storm
Nozzles type		ATR 80 red hollow cone nozzle	ATR 80 orange hollow cone nozzle
Droplets size (test pressure of 1.0 Mpa)	D_{V10} [μm]	38	33
	D_{V50} [μm] (VMD)	102	80
	D_{V90} [μm]	264	164
Active nozzles [N°]		4+4	7+7
Operatin pressure [Mpa]		1.0	1.0
Forward speed [m s^{-1}]		1.39	1.39
Volume rate [l ha^{-1}]		737	934
Fan air flow rate [$\text{m}^3 \text{h}^{-1}$]		28800	30000

For each trial three replicates were made. At the end of each test the sprayed artificial collectors were recovered in closed boxes to prevent light degradations (coveralls were sectioned into 7 parts according to Figure 1 and Table 2, and then recovered). For each test carried out a sample of the spray liquid applied was taken from the sprayer tank to have a reference of the concentration of the tracer in the test liquid.

Afterwards, at laboratory, samples were analyzed washing the sprayed artificial collectors, measuring the amount of deionized water used for wash them and analyzing the

obtained liquid by means of a spectrophotometer (Biochrom Lybra S11) set at 434 nm wavelength, corresponding to the peak of absorption of the Tartrazine dye.

Statistical analyses were done using IBM SPSS Statistics (Statistical Package for the Social Sciences) for Windows (Version 22.0., Armonk, NY: IBM Corp.). For each trials, a bivariate Pearson correlation was performed between the different type of collectors.

Results

All tests were conducted with a wind speed of more than 1 m s^{-1} and a wind direction between 60° and 120° respect to the sprayer travel direction. Temperatures during the tests were around 19.4°C (Min 17.3 and Max 21.6°C) and relative humidity between 70.3% and 76.4%. All the environmental parameters resulted in line with the requirements of ISO 22866.

First trial, years 2013 - Tracer recovered on the mannequins (synthetic filters VS coveralls)

The means of the tracer specific amount ($\mu\text{l}/\text{cm}^2$) recovered on the synthetic filters placed on the different mannequins positions and on the coveralls different parts are shown in in Table 4. In Figure 3 is reported the relationship between the specific amount of tracer recovered by the filter collectors and by the different part of the coveralls. For this analyses the amount of tracer detected on the sectioned coveralls were related to the mean of the quantity of tracer detected on filter collectors gathered by shared coverall sectioned part body in accordance to that shown in Table 2.

The mean quantity of deposit on whole mannequins detected with synthetic filter (19 collectors for a total surface of 0.38 m^2) was $3650.4 \mu\text{l}$, $457.8 \mu\text{l}$ and $238.3 \mu\text{l}$ respectively at 1, 3 and 5 meters from the treated area; the quantity detected using a coveralls (total surface of was 1.943 m^2) was $92.4 \mu\text{l}$, $7.8 \mu\text{l}$ and $1.5 \mu\text{l}$ respectively at 1, 3 and 5 meters. Comparing the two type of artificial collectors the specific quantity recovered in synthetic filter was 40, 59 and 159 superior respectively at 1, 3 and 5 meters from the treated area. This differences are due to their nature: the filters have small dimensions (200 cm^2) and could only be completely exposed (collectors placed in front side mannequins) or fully hidden (collectors placed in back side mannequins); on the other side the coveralls have a larger surface area (about 5 times greater) and while also having a part fully exposed (front side) and a part completely hidden (back side) is characterized by a continuum of surfaces which vary between the two extremes. Table 4 show that more variability of results was found using a synthetic filter (in some cases CV more than 100%) and that variations in deposition tracer detected in the different body parts, at all distances, are less marked using coveralls (the highest CV was 32%). Figure 5 shows that there is not a relationship between the deposition on mannequins measured using filters and coveralls collectors at 3 and 5 meters of distances from the sprayed area. At 1 meter from the treated area there is a significant correlation ($p=0.033$); however this tendency is explained by the values obtained in back body part (fully hidden) with very low deposition values.

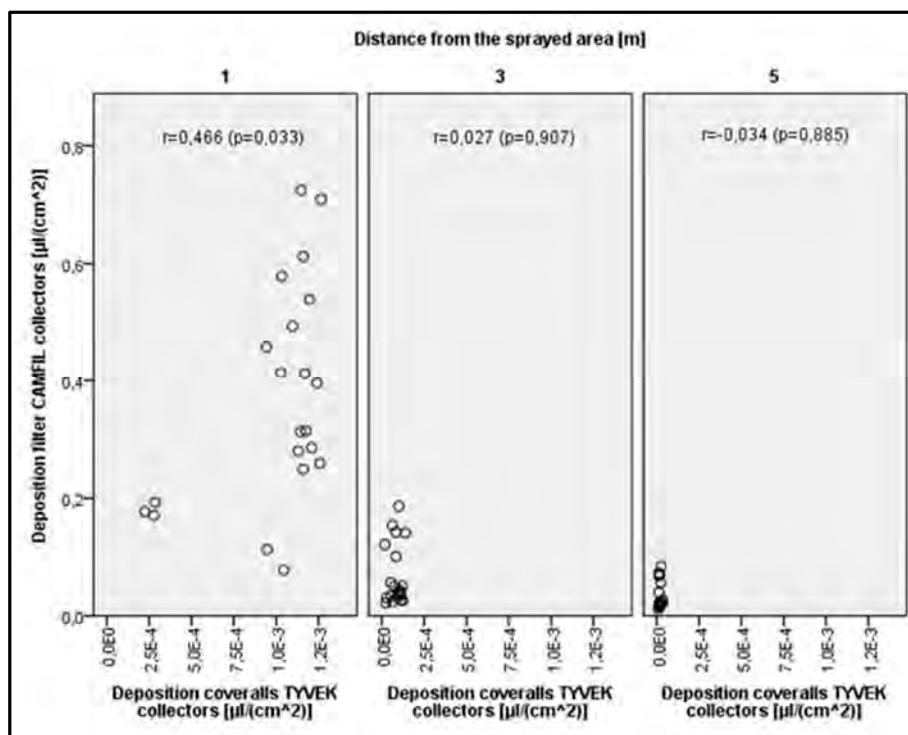


Figure 3. Relationship between the amount of tracer recovered by the filter collectors and coveralls collectors at the different sampling distances (1, 3 and 5 meters).

Table 4. Amount of tracer recovered by the synthetic filter and coverall collectors placed on the adult mannequins at the different sampling distances (1, 3 and 5 meters).

Shared body parts	Synthetic filter collectors							Coveralls collectors						
Leg right	ID number according to the Figure 1	Distance from the treated area [m]						ID letter according to the Figure 1	Distance from the treated area [m]					
		1		3		5			1		3		5	
		Deposition [μl/cm ²]	CV [%]	Deposition [μl/cm ²]	CV [%]	Deposition [μl/cm ²]	CV [%]		Deposition [μl/cm ²]	CV [%]	Deposition [μl/cm ²]	CV [%]		
	1	0.176	36	0.062	77	0.037	100	A	1.23E-03	3	9.40E-05	12	1.66E-05	21
2	0.851	37	0.084	63	0.026	85								
3	0.192	29	0.051	99	0.049	50								
4	0.972	22	0.092	100	0.040	87								
average	0.548	29	0.072	84	0.038	78								
Leg left	5	0.133	4	0.058	77	0.045	85	B	1.12E-03	7	1.11E-04	10	1.56E-05	13
	6	0.654	63	0.099	58	0.044	103							
	7	0.127	62	0.049	62	0.028	63							
	8	0.608	38	0.157	128	0.022	75							
	average	0.380	46	0.091	92	0.035	85							
Arm right	9	0.973	28	0.076	110	0.032	65	C	1.16E-03	1	9.64E-05	32	1.70E-05	13
	10	0.406	31	0.042	62	0.020	106							
	11	0.671	34	0.100	110	0.060	77							
	12	0.282	51	0.075	81	0.037	85							
	average	0.583	27	0.073	96	0.034	80							
Arm left	13	0.074	48	0.061	63	0.032	45	D	1.04E-03	10	1.21E-04	14	2.06E-05	17
	14	0.150	49	0.065	91	0.033	106							
	15	0.819	20	0.079	107	0.029	26							
	16	0.537	10	0.069	101	0.041	57							
	average	0.395	19	0.068	92	0.037	58							
Chest	17	0.346	6	0.063	52	0.027	43	E	1.19E-03	7	8.46E-05	12	1.48E-05	16
Head	18	0.157	69	0.038	43	0.044	78	F	1.04E-03	9	5.64E-05	10	3.18E-05	15
Back	19	0.180	37	0.058	94	0.033	95	G	2.62E-04	13	2.29E-05	18	1.25E-05	18
Total deposition amount of all collectors placed on each manne quins [μl]		3650.448	46	457.807	22	238.306	10		92.428	3	7.812	9	1.500	12

Second trial, years 2014 – Airborne spray drift collectors (Petri dishes VS Polythene lines)

Table 5 shows the amounts of airborne spray drift recovered by Petri dishes and Polythene line (used previously by Cross et al., 2001 and Butler Ellis et al., 2014) at different sampling heights on the ground and at two distances (5 and 10 meters) from the treated area. The sampling height for the Petri dishes stops at the height of 4 meters and for the vertical Polythene line stop at 7 meters.

The data of deposition on the collector used for the assessment of the airborne spray drift point out a greater collection using the Petri dishes mounted on vertical mast. The quantity intercepted by the two type of artificial collectors are different, especially at 10 meters from the treated area, due to the different collector surface (153.938 cm² for Petri dishes against 62.172 cm² for polythene line). The quantity detected at different heights from the ground has the same trend for both sampling distances 5 and 10 meters. The Figure 4 shows the relationship between the quantity of spray drift recovered from the petri dishes and portion of polythene lines placed at the same height (only shared data used for correlation). At distances of 5 m there is not a relationship between the deposition on Petri Dishes and polythene lines. A significant correlation was detected between the two types of collectors at 10 meters from the treated area (p=0.028). Table 5 show that more variability of results was found using a Petri dishes collectors, especially at 10 meters from the treated area (highest CV 65%). Sometimes the CV values of tracer deposition detected on polythene lines show a high value (CV 70%) but overall are broadly less marked (CV between 8 and 20%).

Table 5. Amount of tracer recovered by the airborne drift collectors (Petri dishes and Polythene lines) at the different sampling distances (5 and 10 meters).

Height collectors on the ground according to the Figure 2 [m]	Petri dishes collectors				Polythene line collectors			
	Distance from the treated area [m]				Distance from the treated area [m]			
	5		10		5		10	
	Deposition [μl/cm ²]	CV [%]	Deposition [μl/cm ²]	CV [%]	Deposition [μl/cm ²]	CV [%]	Deposition [μl/cm ²]	CV [%]
0.5	2.196	13	0.888	44				
1.0	2.248	13	1.115	26	2.522	18	0.291	16
1.5	1.534	19	0.970	37				
2.0	1.412	31	0.572	54	1.670	17	0.091	8
2.5	1.575	29	0.413	61				
3.0	2.234	40	0.398	65	0.922	70	0.063	15
3.5	1.835	42	0.307	60				
4.0	2.440	39	0.411	54	0.717	8	0.069	17
4.5								
5.0					0.438	14	0.069	15
5.5								
6.0					0.086	8	0.055	15
6.5								
7.0					0.013	20	0.012	20

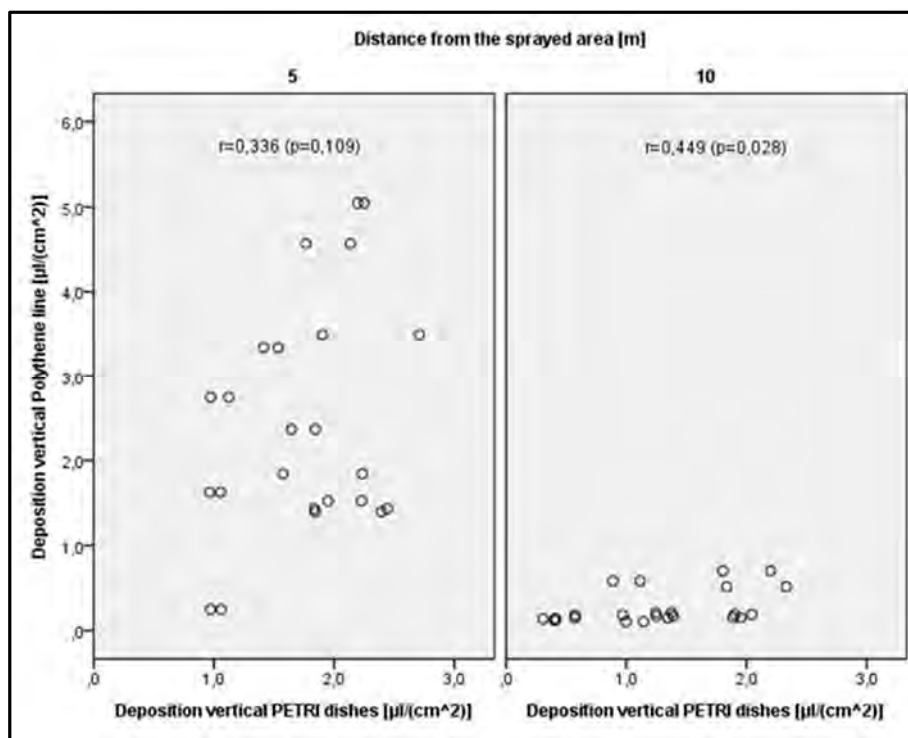


Figure 4. Relationship between the amount of spray recovered by the Petri dishes and Polythene vertical line at the different sampling distances (1, 3 and 5 meters).

Conclusions

Different artificial collectors types used in trials for the measurement of the potential bystander exposure due to vineyard pesticide applications have been studied and shown to be hardly comparable. The collection surface area and efficiency of collection play a fundamental role in the assessment of airborne spray drift and bystander exposure but for the assessment of dermal exposure (bystander) the shape of the collector used it is the main issue. For the before mentioned explanations there is the need to work in a standardized manner using the same type of collectors and test layout. On the basis of the experimental experiences, a visual pattern for propose a test methodology layout combined with the existing ISO22866 is showed in the Figure 5.

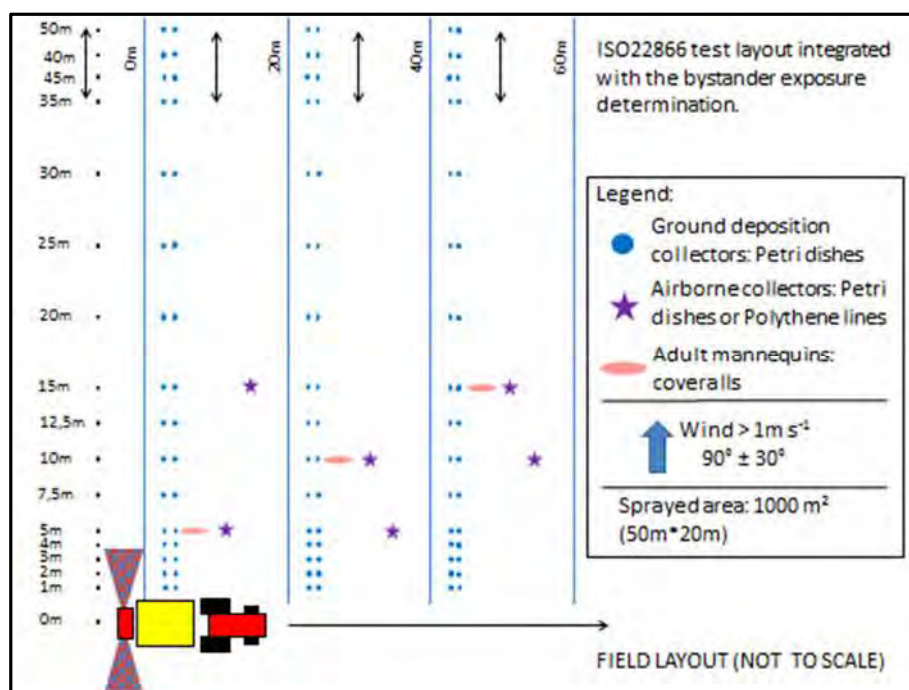


Figure 5. Combined ISO22866 methodology for the evaluation of bystander exposure, airborne spray drift and ground sediment depositions.

This is a preliminary proposal that requires further study regarding the suitable types of collectors and the suitable layout.

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A survey on work safety in 103 agricultural farms in Friuli Venezia Giulia

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Abstract

The objective of this study was to investigate current levels of work safety in agriculture, based on interviews conducted in a composite sample of 103 farms located in the region Friuli Venezia Giulia (North-East of Italy). The survey has outlined a number of patterns that were consistently found across all types of farms and only slightly varied depending on farm size, type of production and location. The results were used to define guidelines for safety experts on the field with new, updated approaches for risk assessment and accident prevention in the farms.

Introduction

Agriculture is one of the most hazardous sectors of economic activity in Italy, in relation both to injuries at the workplace and occupational diseases. More important, the frequency of fatal accidents is particularly high, although not well recognized since many of them involve unprofessional conditions such as retired persons or young people. This makes it very important to properly assess work safety conditions.

Specific surveys on health and safety conditions of working people have been conducted at both European and national level. Recently, the Ministry of Health has promoted a Research Programme on occupational safety and health. One of the priorities has been to establish a national, permanent infrastructure to monitor how workers awareness about risks at the workplace, consistently with the objectives of the National Health Service (Servizio Sanitario Nazionale; Inail, 2014). This kind of investigation is based on telephone surveys involving both the workers and their employers. Another survey was conducted in the agricultural sector (Rete Rurale Nazionale, 2014) based on face-to-face interviews conducted by specialists.

The legal framework in Italy has evolved in recent years, following the adoption in 2008 of Decreto Legislativo (Decree) n. 81 of April 9, 2008, on the regulation and enforcement of workplace health, safety and welfare. This fundamental text (Testo Unico), modified by Decreto Legislativo No. 106 of 2009, contains 306 articles and 51 attachments and introduces the principle of organisation in risk prevention, since both the employers and the workers are committed to safety management practices.

Unlike other European legal standards (e.g. for food safety, environment protection of animal welfare), work safety standards are not part of the common rules for direct support schemes under the European common agricultural policy. However, compliance with work safety rules and national guidelines is required by many Italian Regions as a mandatory condition in order to apply for public support schemes, including those of the Rural Development Plans.

As indicated by previous work, risk prevention and safety rules, while representing substantial requirements for any agricultural farm, are often difficult to introduce and partly still unattended in many cases (Cividino et al., 2010, 2012, 2013). Thus, the first objective of this study was to investigate current levels of work safety in a sample of 103 agricultural farms located in the region Friuli Venezia Giulia (North-East of Italy). Another objective was

to define guidelines for safety experts on the field with new, updated approaches for risk assessment and accident prevention in the farms.

Materials and methods

The data used in this study derived from two separate surveys, conducted to assess safety levels in the Animal husbandry sector and in the Vine growing – Wine producing sector in the Region Friuli Venezia Giulia. In the second case, a number of other farms with different specialisation or mixed production were also included. For the purpose of the present study, this made up a sample of 103 agricultural farms, with a prevalence of dairy farms and farms with vineyard and/or horticultural crops (Table 1).

Table 1. The farm sample.

Type of farm	No.	%	Average size (ha)
Dairy farms	36	35.0	67.5
Other livestock	17	16.5	89.9
Vineyard and winery	24	23.3	55.6
Horticulture and nursery	12	11.7	9.4
Other	7	6.8	14.9
Mixed	4	3.9	240.5
Cereal crops	3	2.9	42.3
All farms	103	100.0	63.9

These farms were located in all of the six Health Districts in Friuli Venezia Giulia, each controlled by the respective District Agency (Azienda per l'Assistenza Sanitaria, AAS). Part of these farms (56.3%) employed hired personnel, while 43.7% were family farms, allowed by the law to use a simplified safety management scheme.

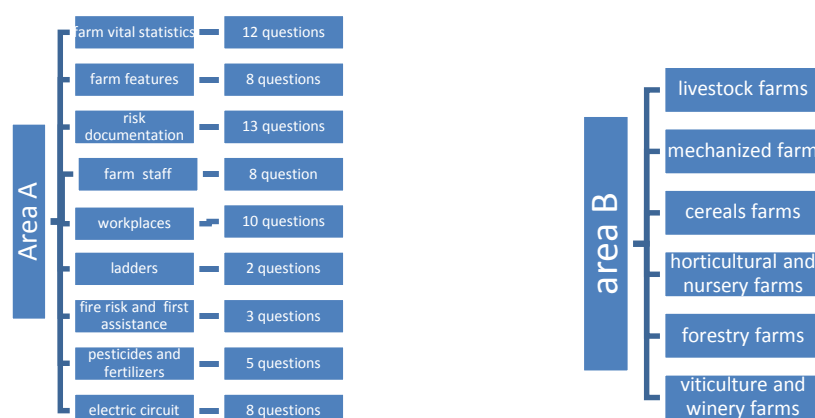


Figure 1. Areas A and B.

Each of the farms was visited by one evaluator and all data were recorded following a specific questionnaire. This was divided in two areas (Figure 1):

- area A, including general information about the farm;

- area B, which varied depending on farm specialisation, and was further divided into three profiles: B1: farm machinery; B2: personal protective equipment (PPE); B3: specific risks.

Results

To the purpose of the present study, we analysed:

- whether official documents and records were actually present at the farm;
- how safety management was organised;
- the presence of protection devices on tractors;
- the use of prevention and protection equipment.

Table 2. Official documents at the farm.

Type of document	Missing or inadequate (% of farms)
Risk assessment document	34.5
Risk assessment update	44.8
Medical watch	34.5
Emergency procedures	41.4
Regular inspection record (lifting equipment)	44.8
Compliance certificate of equipment	10.3
Book of use and maintenance	8.6
Pesticide license	24.1
Pesticide safety sheet	25.9
Equipment maintenance plan	36.2

Table 2 includes only the 58 farms with external personnel, which are subjected to full application of Decreto 81/08 including official documentation. The main document required, i.e. the Risk assessment document, was absent or inadequate in 34.5% of the farms; other required documents were missing even more often, including a scheme for medical surveillance of workers (34.5), the scheme for emergency procedures (41.4%), and the record of periodic inspection of lifting equipment (44.8%). Only those documents provided by third parts were mostly present, such as the Compliance certificate (lacking in 10.3% of farms), the Book of use and maintenance of equipment (8.6%), the Pesticide safety sheet (25.9%), or those required for purchasing pesticides (Pesticide license: 24.1%). Particularly remarkable was the absence of a plan for machinery and equipment maintenance (36.2%), because of its great importance for accident prevention.

The law also requires every farm with hired personnel to officially appoint a number of figures in charge of the different protection and prevention services (Table 3). While a safety manager (or head of the prevention and protection service, PPS) was mostly present (82.8% of the farms), other figures were often missing, including a doctor designated for periodic medical surveillance (48.1% of farms), or the supervisors for fire prevention (33.3%), first aid (34.6%) and workers' safety during actual work (63.0%). Additionally, 38.3% of the farms were not providing the workers with sufficient training and information services, while 44.3% did not have any special training for the various managers and supervisors.

Table 3. Managers and services.

	Not present (% of farms)
Safety manager	17.2
Medical doctor	48.1
Fire prevention manager	33.3
First-aid manager	34.6
Workers' supervisor	63.0
Training and information service (workers)	38.3
Special training service (managers)	44.3

Most of the farms had adequate toilet and shower services and dressing rooms for the workers (Table 4). The width of the main entrance to the farm (minimum: 5 m) was mostly in line with the law. Protections on gaps or trenches were, however, missing in 28% of their farms. Most remarkable was the absence of any Interference risk analysis, i.e. a plan to avoid risks owing to the presence at the farm of external personnel, especially contractors for cereal or grape harvesting. Only 8.6% of farms had conducted a proper analysis of such risks.

Table 4. Situation of buildings in the farm.

Building services	Yes (%)	No (%)
Toilets	93.9	6.1
Showers	87.2	12.7
Dressing room	86.4	13.5
Main entrance to farm > 5 m	81.3	18.6
Railing on hole, trench	71.8	28.1
Interference risk analysis	8.6	91.4

In approx. one half of the farms, a specific analysis was made to assess the main features of the tractors (Table 5). The average nominal power was 63 kW, and the average age was 20.9 years. The average annual usage (328 h/year) was related with the small average land area (63.9 ha, Table 1), and was far from the level suggested for profitable management (at least 600 h/year). These data offer some clues as to the current difficult economic situation in most of the farms: the reasons are many, which cannot be fully discussed here. Anyway, this makes even more difficult for these farms to bear the costs involved by current requirements for risk prevention and protection.

Table 5. Tractors at the farms.

	no. of tractors	Power (kW)	Age (years)	Usage (hours)	Usage (hours/year)
Dairy farms	54	76.6	20.7	7339	355
Other livestock	18	65.6	21.6	7078	328
Viticulture	62	57.1	15.3	4444	290
Horticulture and nursery	26	50.3	27.8	3610	130
Other	2	40.4	24.8	1750	71
Mixed	29	61.8	26.1	15329	588
Cereal crops	5	64.7	20.0	6958	348
All farms	196	63.1	20.9	6873	328

In fact, missing protection devices are mostly related to the tractor's old age. In most of the sample farms, tractors were equipped with roll over protection structures (ROPS), protection of moving parts such as belts and fans, and of hot surfaces (Table 6). Remarkably, however, a safety belt was missing at the driver's seat in 55.1% of the tractors (it is compulsory since 2005); PTO guards were also missing in 24.7% of the tractors.

Table 6. Protective devices.

Protective item	missing (% of tractors)
ROPS	5.2
Safety belt	55.1
Protection of belts & fans	7.6
Protection of hot surfaces	10.8
Safe access to driver seat	13.6
PTO guards	24.7
CE marking	37.6
Owner handbook	8.0

The relationship between the presence of protective items and the tractor's age is shown in Figure 2. All of the new tractors were in line with legal requirements; the only exception was a safe access to the driver's seat, which is often difficult to attain especially in small tractors for viticulture. This means that the main problem for these farms is the low investment capacity, that prevents them to replace old tractors with new ones.

Figure 2. Tractors with required protective items in place.

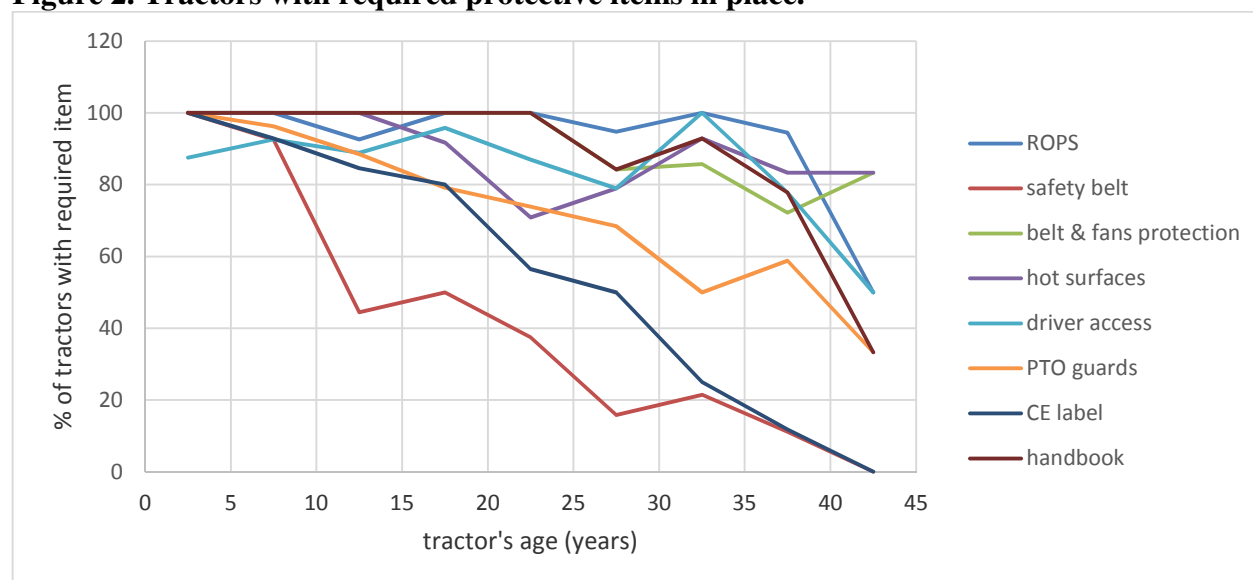
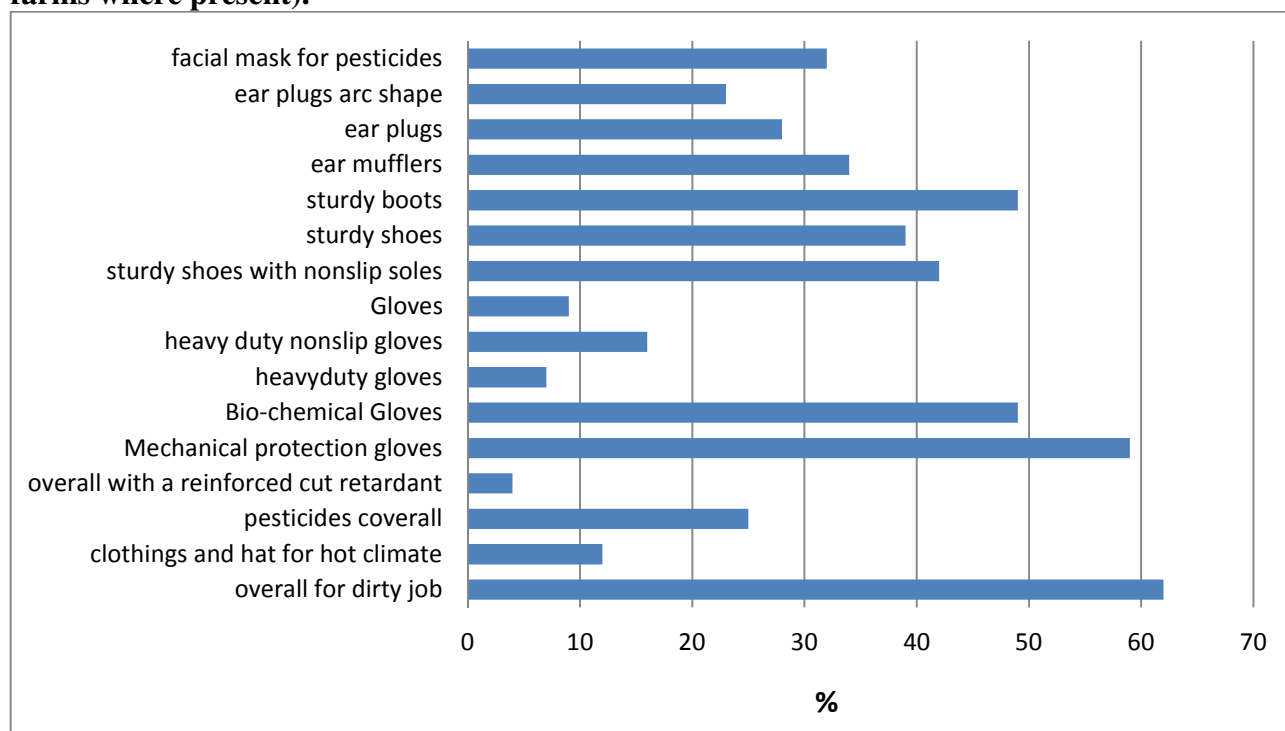


Figure 3 shows the percentages of farms that were providing their workers with personal protection equipment (PPE). In general, only basic PPE were present (like overalls in cotton and mechanical protection gloves), while specific PPE were seldom found (such as ear muffs, safety footwear, chemical resistant clothing and gloves).

The main findings from the survey suggested that many agricultural farms were sufficiently aware of the risks associated with their specific production systems, or with the

machinery used, but had a tendency to neglect them to some extent, particularly in order to avoid the related economic costs. More important, information about legal obligations was generally insufficient, as was the understanding of the possible cost, in terms of fines, damage compensations and similar, that failure to comply with the rules might cause.

Figure 3. Types of personal protective equipment (PPE) provided at the farms (% of farms where present).



This suggested that most farms would take advantage of some simple informative tool, e.g. in the form of a software, in order to quickly detect the most critical situations. This software, based on a Microsoft Excel® worksheet (Figure 6), enables the farmer to check all the legal requirements for tractors and the main agricultural implements, and suggests how to amend possible defects.

For example, it is possible to examine the existing ROPS on a tractor (Figure 7) and understand whether it fulfils legal requirements or needs changes or replacement; or, indications are given about how to install a ROPS on an old tractor.

Conclusions

The survey was important to improve current knowledge about work safety in agricultural farms, and was also useful to increase the farmer's awareness about the specific risks involved by the different production systems.

A further step will be to improve safety conditions through proper informative and self-assessment tools. Since the survey had shown that most of old tractors and machinery were defective in one way or another, we prepared a software to help the farmer check each machine and detect any improper or missing protective device, or to amend it in order to fulfil legal requirements.

Finally, this work was instrumental to building a data base about current situation of agricultural tractors and implements in use in the Region Friuli Venezia Giulia.

Figure 6. Software menu for check safety device in the tractors.

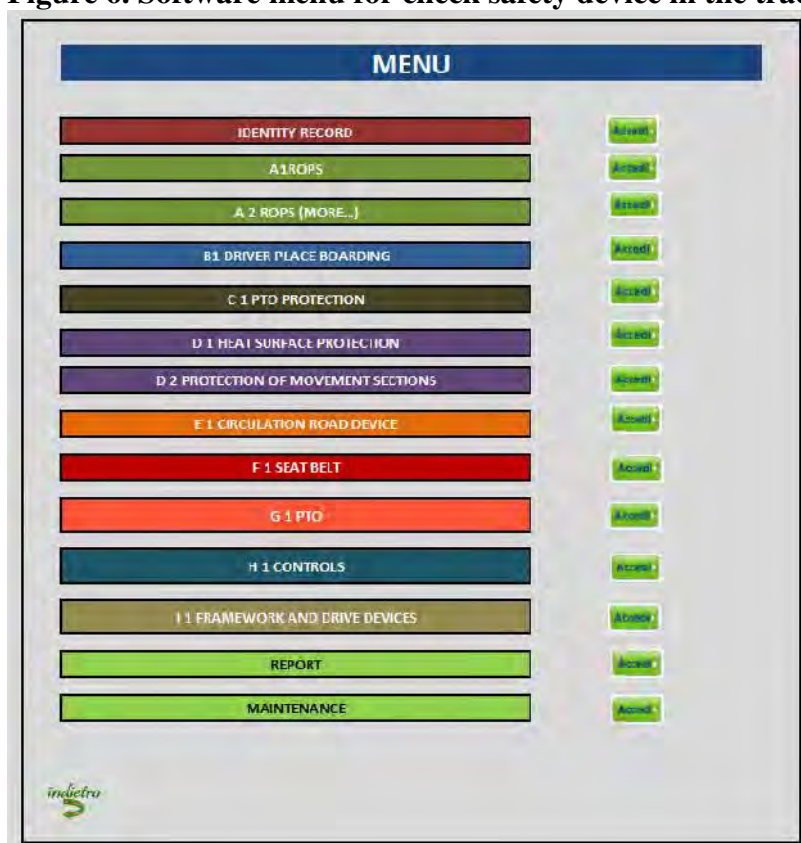


Figure 7. Menu section of tractor ROPS.

41			ROPS		
Contro	Visual				
Sezione	Controllato da	Condizione			
A.1.1	ROPS	control ok			
A.1.2	strut number	not controlled			
A.1.3	Installation	not controlled			
A.1.4	bendable ROPS	not controlled			
A.1.5	Installation certificate	not controlled			
A.1.6	Strain 10°S	not controlled			
A.1.7	Identity Tablet	not controlled			

ROPS		
part. assessed	Present	Assessment
The visual analysis must assessment if the ROPS is standard or not		assente
kind of intervention	in mancanza del telaio di protezione si dovrà provvedere alla sua installazione presso una officina specializzata. Il telaio dovrà conformarsi alle indicazioni della linea Guida "L'installazione nei sistemi di protezione del conducente nei trattori agricoli o forestali".	

Numero di montanti				
part. assessed	Present			Assessment
L'analisi visiva deve valutare la tipologia di arre di protezione esistente.				
example	2 Struts	4 Struts	CAB	

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A U.S. Approach Towards Safety Education for Youth in Agriculture

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Abstract

In 1968, the U.S. Department of Labor (DOL) initiated the Hazardous Occupations Order for Agriculture allowing youth employment on farms/ranches at the age of 16; students aged 14-15 years could also be employed provided they participated in a mandated tractor/machinery safety program. In the 47 years since legislation, serious deficiencies and variations occurred in the type/quality of training and the overall process for certifying young workers. While a considerable amount of effort and funding was given to update the training, no real changes have occurred. More recently, the DOL attempted to place stricter controls on youth employment and was met with much opposition from the rural community and their agricultural lobbyist organizations. With politics aside, the more important topic was how to safely involve youth in agriculture. The overall objective of this national project was to develop a sustainable and accessible clearinghouse of safety and health curricula for youth workers. A group of dedicated stakeholders received funding by the U.S. National Institute of Food and Agriculture to coordinate a national approach for youth safety education. This plan involved interactions, collaborations, and partnerships from a variety of public and private institutions. The ultimate result was to provide appropriate training to the youth workforce that increased their awareness for hazards and improved safe practices. Along the way, there was a need to build capacity within the system for teacher education and access to quality curriculum, including testing tools that met a national education standard. Likewise, enhancing public perception of legislation was needed before any success could be attained. This paper addresses the steps taken by the national project, and three results attained thus far: 1) a national symposium for stakeholders' input, 2) a national clearinghouse for curricula, and 3) training for school students in a supervised agricultural experience.

Keywords: Young Workers, Training, Public Policy

Introduction

In 1968, the U.S. Department of Labor (DOL) initiated the Hazardous Occupations Order for Agriculture (AgHOs) allowing youth employment on farms and ranches at the age of 16 (U.S. DOL, 2007). Students aged 14-15 years could also be employed provided they participated in a mandated tractor & machinery safety program. The AgHOs have been, and are currently regulated by the U.S. DOL. In the 47 years since legislation, serious deficiencies and variations occurred in the type and quality of training as well as the overall process for certifying young workers. Likewise, changes in agricultural production and the types of tasks youth are performing have changed. The U.S. Department of Agriculture, a federal core agency of the U.S. Cooperative Extension System, dedicated a national program to address trainings and certificate course programs that meet the AgHO requirements. This Youth Farm

Safety (YFS) Program supported national efforts to deliver timely, pertinent, and appropriate trainings to youth seeking employment or who are already employed in agriculture. While these training requirements do not apply to youth working on their family farm, the educational resources represent good agricultural work practices. Because of this, many parents and grandparents consider this training for their family-based youth workers.

Through the YFS program, land grant universities were provided grants to develop current, consistent, and evidence-based curricula. Over the years, some 23 projects were funded for this target audience. Despite these excellent efforts, no official directory or clearinghouse was developed to contain or market the availability of this material – which is generally offered at no cost to the students.

Safety education is just one approach for reducing injuries, illness, fatalities – engineering practices and public policy are two others (Murphy, 1992). However, in the agricultural workplace, engineering controls (i.e. shields, guards, safety interlock devices, and ROPS) can be removed by the user, and are often viewed as a nuisance rather than a protective factor. To compound to the problem, many youth learn to operate farm machinery using the farm’s older equipment, where shields and guards, seat adjustments, and ROPS are completely void.

In 2011, the U.S. DOL proposed policy to strengthen the AgHOs for children working in agriculture. This proposal was met with great opposition from the community. In the U.S. farming is a culture; it is an occupation that enjoys limited controls and governmental oversight. Because of this culture, and the special interest groups that support it, it is difficult to implement and mandate occupational safety and health programs and trainings that may be common in other industries.

Leviton (1991) speculate that people will delay taking action to reduce risk until they first perceive the risk as a significant health threat. “Education can help individuals expand their awareness of risks and increase their skills for dealing with them” (p.233). Safety and health education has become a significant factor in injury intervention and control. Recognizing that prevention is the only sensible strategy in curbing unintentional fatalities on the farm, education provides a framework for increasing knowledge and skills. Education is also critical to inform target populations of public policy as well as benefits of engineering controls. In all aspects of the injury prevention model, there is a need for safety education.

Career Training and Work-Based Learning Programs

In the United States, youth desiring a career in agriculture have formal public school technical training provided through an approved agricultural education program. These programs offer supervised agricultural experiences (SAE), which are philosophically designed to provide guided experiential learning beyond typical school hours (Phipps, Osborne, Dyer, & Ball, 2008). Students completing SAEs as part of an agricultural education program apply concepts learned in the classroom or laboratory to real world applications (Dyer & Osborne, 1995; Phipps, Osborne, Dyer, & Ball, 2008; Croom, 2008). Learning activities are to be planned intentionally to develop students’ skills and abilities that will culminate toward a career in agriculture (Barrick, Arrington, Heffernan, Hughes, Moody, Ogline, & Whaley, 1992). The number of agricultural education programs is estimated to be 610,240 students nationwide enrolled in 7,665 school-based agriculture programs (National FFA, 2014). Roberts and Dyer (2004) identified that developing SAE opportunities for students was among the highest professional development need for secondary school agricultural instructors. However, with the large number of students engaging in the SAE’s, it is imperative to understand supervision strategies and safety guidelines provided by the agricultural education professionals.

When placed in an SAE, it is typical for students to work alongside the co-workers or supervisors. This could lead to exposing students to uncontrolled interaction with potential risks while supervisors are busy with their own work responsibilities. Sanderson, Dukeshire, Rangel, and Garbes (2010) concluded that as individuals progressed through childhood to young adult, they developed clear ideas about how to farm safely and that observational learning and modeling were key components of the apprenticeship process. There is a significant need to provide professional development and curriculum to assist SAE supervisors in protecting and shaping our future leaders in agriculture. An increased awareness about agricultural injuries and their prevention is essential in the development of culturally and geographically relevant safety instruction and supervision strategies.

Stakeholder input

During a public forum meeting conducted by the U.S. Department of Agriculture – National Institutes for Food and Agriculture (USDA-NIFA, 2012), stakeholders acknowledged the critical roles adults have in designing and implementing youth farm safety education programs. These stakeholders did more than express their concern over the lack of comprehensive training curricula available to young farm workers, they also reported a strong need for a youth farm safety curriculum that is ecologically sound, developmentally appropriate, innovative, time relevant, exceeds the minimum requirements of the current AgHOs, and reflects current approaches in pedagogy and knowledge of youth-related injuries in agriculture. Most stakeholders felt that creating a centralized source for educational and training materials would be helpful, and that a national curriculum should follow national education standards already being used in career pathways knowledge and skill sets.

Related to partnerships, the stakeholders also felt it beneficial to implement a comprehensive youth training program with coordinated collaborations from associations, schools, and organizations that are currently implementing safety programs, as well as partnerships with parents, health community educators, farm labor organizations, local farm & ranch organizations, Cooperative Extension, Future Farmers of America (FFA), National 4-H, agricultural equipment manufactures, commodity groups, the National Institute of Occupational Safety & Health (NIOSH), the U.S. Department of Labor and the Agricultural Safety and Health Council of America (ASHCA).

Another resource of the U.S. land grant system is eXtension (pronounced E-extension). This electronic system is integrated within the land grant universities as a partnership for shared knowledge and educational resources, delivered via the Internet through community-based educational programs. This collaborative effort provides public access to training materials and informational resources 24/7/365 via website (<http://www.extension.org>). A specific component of the eXtension network addresses farm and ranch safety and health topics (eXtension, 2011). At this time, a network of 90 Community of Practice (CoP) members use their expertise to develop site content through a peer reviewed process which requires a minimum of two reviewers per article. Content on this eXtension site includes articles by topic, educational and outreach materials, national reference documents and visuals, and national resource organizations. The mission of this electronic network is to become the primary resource library for all agricultural safety and health information for use by agricultural producers, professionals, educators and rural people.

With such a broad array of interest groups, educational opportunities, and politics, an opportunity existed within the United States to address a modern public health and safety problem regarding youth workers. The primary topic discussed within stakeholder groups was

‘how’ to safely involve youth in agriculture. The overall objective of this project was to develop a national strategy that would enhance awareness of, access to, and utilization of farm materials for youth workers and those adults who instruct or employ youth.

Methods

In 2013, a group of educational specialists from land grant universities received funding from the U.S. National Institute of Food and Agriculture to coordinate a national approach for youth safety education. The Safety in Agriculture for Youth (SAY) Project was funded as a collaboration between Pennsylvania State University, The Ohio State University, Utah State University, University of Kentucky, and Career Safe, Inc. (a private education corporation). The primary mission of the SAY Project was to develop a sustainable and accessible national clearinghouse for agricultural safety and health curriculum for youth in both formal and informal settings. Several secondary objectives were established to improve communication and collective cooperation from multiple stakeholders with similar interests. All curriculum efforts were to increase safety and health knowledge and reduce hazard and risk exposure to youth on U.S. farms and ranches. This national curriculum is not a ‘curriculum’ per se, but is an umbrella compilation that includes many different curricula, programs, projects, and activities that together have a common purpose. Additionally, this comprehensive national curriculum was developed to be sensitive to all types and scales of production agriculture and all ages and experience levels of youth audiences. It must include parents, employers, and other educators. It must be culturally appropriate. And it must be usable in both formal and informal educational settings.

Under this public funding, four specific aims guided the approach. Three results are collectively reported in this paper.

Specific Aim 1: Conduct a youth farm safety symposium to engage the various stakeholder groups and build synergy for the overall SAY program initiatives. This public symposium involved SAY National Steering Committee members and their root organizations, other interested organizations, government agencies, and commodity groups with youth educational resources.

Specific Aim 2: Create a centralized location (National Clearinghouse) of relevant educational materials that can be used in both formal and non-formal educational settings for youth.

Specific Aim 3: Establish a risk assessment protocol for developing supervision strategies and guidelines for formal secondary students’ experiential learning activities (i.e. Supervised Agricultural Experiences).

Results

The ultimate results were to provide appropriate training to the youth workforce so that they could have increased awareness for hazards and improved work practices. At the onset of this process there was a need to build capacity within the system for teacher education and access to quality curriculum, including testing tools that met a national education standard. Likewise, enhancing public perception of legislation was needed before any success could be attained. Outcomes of three aims are reported here.

Outcome from Specific Aim 1: A National symposium of stakeholders’ input

The national symposium provided interaction and discussion amongst stakeholder groups, educators, parents, and agricultural employers who provide and/or seek training opportunities for youth workers. The concise workshop-style format consisted of two half-day technical

sessions, whereby the program started at 1pm on the first day and ended at noon on the second. An evening dinner and social was included on Day 1 to allow for informal discussion and networking opportunities. Forty-five stakeholders participated in the symposium, representing 7 academic institutions and 11 other agencies.

Four plenary sessions were developed with unified themes and national speakers. The purpose of each session was to evoke constructive dialogue to bring about ideas, share resources, identify gaps, and discuss best practices for safely involving youth on the farm or ranch. These discussions were not only important for employed youth, but also those who may work for family agricultural operations. The plenary sessions included: 1) Current Regulations, 2) Employment Options in Agriculture, 3) Age Restrictions versus Competence Standards for Involving Youth, and 4) Formal versus Non-Formal Training Resources. Each session was video recorded and available on the project’s clearinghouse website.

Evaluation data was collected from participants, reflecting a 44% response rate. Using a 5-point Likert scale, 100% of the participants agreed that speakers were knowledgeable, content was presented with a good flow, and topics were reflective of the latest developments in agricultural safety for youth. Approximately 85% were in agreement with the panel-style sessions as an effective way to learn the information, and offered comments like: “I really liked the two-day format; it was intense, but helpful” and “Each speaker brought great information into the symposium.” Fifteen percent of participants rated the Question/Answer sessions higher than the panel sessions with comments including: “The Q&A sessions were the most valuable aspect of the event.” Over 95% of the participants reported the symposium met their expectations.

Outcome from Specific Aim 2: A National clearinghouse for curricula

Steps were put in place to develop a national clearinghouse specifically for agricultural safety and health curriculum. A national steering committee and three stakeholder groups were formed to offer the project team guidance, as well as assistance in identifying appropriate content to be submitted to the clearinghouse. A marketing and outreach plan was developed to ensure national awareness and easy access/utilization of those materials. Also, a website was established to serve as the central location for the training materials.

An online submission process was developed for easy submission of educational materials. Content could be cataloged by curriculum, education resource, or video link. It was important for the clearinghouse to be sustainable, so in that regard, steps were put into place that ensured 1) links were made to existing educational resources, 2) curricula included formal (school) and non-formal (home and agriculture) resources, and 3) resources were marketed for all audience groups, including youth workers, parents, educators and agricultural supervisors.

Outcome from Specific Aim 3: A supervised agricultural experience training program

Agricultural education teachers are in a prime position with SAE’s to influence the safety culture and protect their students while working in the agricultural industry. Two approaches were taken within this aim.

1. Assess U.S. public school agriculture instructors’ professional development needs and safety practices for protecting youth involved in supervised work based agriculture experiences.
2. Develop a professional development program for public school agriculture instructors

to monitor supervised work based agriculture experiences for hazards and implement safety interventions to reduce injury risks to students.

The first approach utilized the theoretical framework of the theory of reasoned action and planned behavior (Ajzen, 2005; Ajzen & Fishbein, 1980) which has been used to explain the significant association between health attitudes and risky behaviors. The purpose was to gather evidence of agricultural education teachers' beliefs towards supervision and planning practices for student safety during SAE activities.

Agriculture teachers rated 60 items on level of agreement (5 = “Strongly Agree”, 1 = “Strongly Disagree”). A panel of five university agricultural education teacher educators with expertise in supervised agricultural experiences reviewed and determined the survey was content and face valid. Cronbach's coefficient alpha reliability estimates were used to determine the instrument reliability. A total of 263 surveys were returned with 232 surveys complete and useable for a response rate of 19.2%. Multiple contacts were made to encourage non-respondents to participate in the survey. Telephone follow-ups were conducted with a random sample of 300 non-respondents. All statistical tests were set at an alpha level of .05 a priori. There were no statistically significant differences between early and individuals responding to telephone follow-ups. IBM SPSS Statistics version 20 was used for data analysis. Research questions were analyzed descriptively with frequencies, percentages, means, and standard deviations. For items where the standard deviation exceeded the mean, the median (*Mdn*) and interquartile range (*IQR*) were reported.

The average age of agriculture teachers completing the survey was 41 years old (*SD* = 11.1). The majority of respondents (62.9%, *n* = 144) self-identified their gender as male. Over half of the respondents (56.5%, *n* = 130) indicated having completed a master's degree program at the time of the survey. The majority of agriculture teachers (65.2%, *n* = 150) indicated being a single teacher program. For the number of students enrolled in respondents' programs the median was 100 (*IQR* = 98). For the number of students enrolled with an active approved SAE in respondents' programs the median was 50 (*IQR* = 70). A total of 122 respondents (54.2%) indicated the most commonly completed SAE type was placement followed by 101 respondents (45.5%) who indicated entrepreneurship was the most commonly completed SAE type in their program. The construct “SAE Safety Procedures Perception” had the highest level of agreement (*M* = 4.12, *SD* = 0.50) among Agriculture teachers. “Professional Development Need” ranked second (*M* = 3.93, *SD* = 0.59) followed by “Mentor Involvement” ranking third (*M* = 3.72, *SD* = 0.63) and “Hazardous Work Perception (solitary student SAE tasks) ranking fourth (*M* = 3.37, *SD* = 0.78) in the level of agreement among respondents.

The second approach taken within Aim 3 included a professional development workshop conducted for secondary agricultural teachers regarding supervised agricultural experiences and student safety planning.

Using NIOSH FACE reports of childhood injuries as case studies, teachers were given a demonstration of how to utilize Haddon's Injury Model for evaluating work environments for uncontrolled interactions between a host, an agent, and the environment (Haddon, 1980). The demonstration guided teachers on pre-event phase and event phase supervision for following safety guidelines when working with agricultural machinery and livestock. The workshop instructed secondary school agriculture instructors on the development of informational resources that are meaningful, barrier-free, and culturally sensitive to their community members (Runyan, 1998). Secondary agriculture education teachers from Region I NAAE (*N* = 15) were surveyed at the NAAE Region I conference regarding the professional

development workshop ($\alpha = .76$, 10 items). The workshop survey was reviewed and deemed content and face valid by three agricultural education professional development experts. Teachers were asked to evaluate the workshop using a paper based questionnaire with 10 Likert-scale questions (1=Strongly Disagree; 2 = Disagree; 3 = Not Sure; 4 = Agree; 5 = Strongly Agree) and four open ended questions. Fifteen workshop participants completed the survey. The anonymous nature of participants responses precluded follow up of non-responding workshop participants.

The majority of teachers (87%) agreed the workshop was well organized and that main points were clarified, 53% strongly agreed the facilitators demonstrated a comprehensive knowledge about the subject, and 73% agreed that the facilitators conveyed ideas effectively and clearly. The majority of teachers (80%) would like further professional development in the area of supervised agricultural experience and student safety planning. Further, 93% agreed to strongly agreed that the material presented gained usable skills and will be able to apply them to their academic and/or personal life. Finally, 83% found the curriculum CD materials provided were useful. Responses to open ended questions identified the opportunity to share best practices, curriculum materials and the work being done in this area as being most useful, felt it was at the current skill level for teachers, and suggested the facilitators review the contents of the curriculum CD materials.

Through both of these independent assessments, it was learned that agricultural education teachers were in a prime position with SAEs to influence the safety culture in agriculture to protect their students. Individuals participating in this study agreed that secondary agricultural education teachers should require students to follow SAE safety procedures during work. An outcome from these initiatives will lead to the development of SAE supervision and safety “best practices” to assist agricultural education professionals in protecting and shaping our future leaders in agriculture.

Conclusions

The SAY Project was a multi-faceted approach to address a complex health and safety problem in the U.S. workplace. Cognizant that youth populations were at risk for injury and death while working in agricultural settings, a comprehensive strategy was formed and funded by the National Institutes for Food and Agriculture, a division of the U.S. Department of Agriculture (USDA) in Washington, D.C. An effort by multiple academic institutions was implemented to provide appropriate training to the youth workforce that would increase their awareness for hazards and improve safe practices when working in agriculture.

The three results reported in this paper, served as a foundation by which additional projects were implemented under the funding agreement. Having this framework in place, provided a means for centralized access to curriculum, learning activities, youth safety certificate courses, farm safety and health expertise, public policy reference documents, and applied research approaches for formal and non-formal learning arenas.

These results also serve as a means to document the feasibility for developing a culture of safety among youth and leaders in the agricultural industry. A recommendation for health and safety professionals is the consideration of an outreach strategy goal to address public outreach needs for the implementation of youth safety programs (like hazard identification and elimination and promotion of engineering controls). Outreach efforts will continue to involve substantive education, short training courses, live presentations, handbooks, posters with educational content and captioned illustrations, and web-based training modules, or websites for best practices. The USDA project encourages outreach activities that attempt to provide prevention information, education, risk reduction counseling,

referrals, and safety options to populations who work with or supervise youth in agriculture.

A continuation project was funded for 2015-16 with full expectation that additional government dollars will be appropriated towards future projects under this umbrella SAY project structure. The initial project is a testament of the progress that can be made when stakeholder groups work together for the overall well-being of the young workers.

Acknowledgements

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Risks linked to the management of pressured hydrogen within a photovoltaic-electrolyzer-fuel cell power system located on a rural land⁷

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Abstract

A power system formed by photovoltaic panels, alkaline electrolyzer and fuel cell stacks was designed and realized to supply the heating system of an experimental greenhouse. The barometric alkaline electrolyzer produces pressured hydrogen (3 MPa), which is stored inside iron tanks. The aim of this paper is to emphasize the main safety aspects of the power system connected to the management of the pressured hydrogen. From the safety point of view the electrolyzer unit has been equipped with devices able to highlight the malfunctions before they cause damages to the operators and break off the process of hydrogen production. The system can be reactivated after the repair just if the cause of malfunctioning has been removed effectively. Nevertheless the management of the products of the electrolysis process involves forethought and trained operators. Starting from the study of international directives and through the Hazard and Operability (HAZOP) Study method, the standards of safety systems for the hydrogen equipment located on a rural land have been estimated.

Keywords: Hydrogen Hazards Assessment, Water Electrolysis, Rural Lands, Risks Analysis

Introduction

The geothermal heating systems with heat pump may be useful, environmental friendly and economically favorable to meet energy requirements of modern greenhouses for winter heating systems (Vox et al., 2010; Scarascia Mugnozza et al., 2011). The Authors are carrying out a research with the aim to investigate the suitable solutions of a power system, based on solar energy (photovoltaic) and hydrogen, supporting a self-sustained greenhouse heated with a geothermal heat pump. The study is going on at the experimental farm of the University of Bari sited in Valenzano (Bari, Southern Italy), latitude 41° N, where a power system integrated with a greenhouse, composed of photovoltaic panels, an alkaline electrolyzer bank, fuel cell stacks, a plastic greenhouse and a geothermal heat pump were set up (Fig. 1). The electricity coming from the solar photovoltaic source (PV) feeds the electrolyzer; the hydrogen gas produced by water electrolysis is then stored in a pressure tank and, when the photovoltaic is inactive (during night time or overcast sky), it is used by a fuel cell system producing electricity for the greenhouse energy demands (Blanco et al., 2014). The electrolyzer is supplied by a power rating of 2.5 kW at a voltage of 230 VAC and produces a hydrogen nominal rate (dry gas) of 0.4 Nm³/h at 3 MPa. Hydrogen and oxygen bubbles that are generated in the cell stack of the electrolyzer are collected in two separate channels and flow into the gas separators. These are two cylindrical recipients made of stainless steel and half filled with electrolyte where the produced gases are bubbling and separate from the liquid they carry away. The two gases are then filtered, and cross final droplets separators before being delivered from the unit. Hydrogen is routed through a backpressure controller; oxygen

⁷ Each of the authors contributed in equal parts to this work

is vented to the atmosphere. The produced pressurized hydrogen is stored in two steel tanks having a total capacity of 0.6 m³. Furthermore the power system is equipped with pressured nitrogen hold inside metallic cylinders, employed to make unreactive the plant, that is to remove the air inside the system before each restarting of the electrolyzer and immediately after each system failure. The running of the power system and the management of the pressured gases have required a careful risks analysis to safeguard the farmer operators that must be trained to be aware of potential hazards and to take appropriate precautions. In this regard the hydrogen devices, pipes and systems observe the two ATEX directives for the manufacturers (directive 94/9/EC) and for the users (directive 99/92/EC) of the hydrogen equipment. The aim of this paper is to emphasize the main safety aspects of the power system connected to the management of the pressure hydrogen.

Materials and Methods

The entire power system has been designed so that any failure to its components does not compromise the safety of the plant. The different phases of the process (generation and purification of the produced hydrogen by the electrolyzer, hydrogen storage, electric production) are supervised by an automatic control system, designed to ensure reliable safe and efficient effectiveness. The logic underlying the controls has been realized according to a the Hazard and Operability Study (HAZOP) study (Trevor, 2006). As known, the HAZOP Study is a standard hazard analysis technique used in the preliminary safety assessment of new systems or modifications to existing ones; it consists in a detailed examination of components within a system in order to determine what would happen if a component were to operate outside its normal design mode. In the realized power system alarm situations are highlighted and the production process is cut off in safe conditions in the event that the operational parameters have an abnormal deviation from the design values. The reasons that have given raise to alarm are highlighted and the operator is called for an inspection. The system can be reactivated after the repair just if the cause of malfunctioning has been effectively removed.

The electrochemical reaction concerning the water splitting into hydrogen (H₂) and oxygen (O₂) takes place when a suitable DC electric current is applied to the electrodes of the electrolyzer. In an electrolysis cell, an electric current is passed between two electrodes separated by a conductive electrolyte, producing hydrogen at the negative electrode (cathode) and oxygen at the positive electrode (anode). As water is H₂O, twice the volume of hydrogen is produced over oxygen. The gases produced by this process are mutually impure, because of the diffusion phenomenon and this mutual mixing of the two gases, beyond specified limits, may lead to the formation of explosive mixtures. Really the technical standard (ISO 22734-1:2008) requires that the electrolysis process must be stopped at the fulfilment of 2% of H₂ inside O₂ and 1.6% of O₂ inside H₂, without detailing temperature and pressure values.

Results

The electrolyzer (Fig. 2a) has been equipped with an analyser (Fig. 2b) of oxygen and hydrogen on the production line, which gives an alarm signal when the concentrations of oxygen and hydrogen reach respectively 1.1% and 1.6 % and in this last case cut off the electrolysis process. However, in order to provide pure hydrogen to the fuel cell, the percentage of oxygen in the hydrogen in the working conditions is less than 0.01%. The electrolyzer has been located inside a metallic cabinet equipped with a system for the air extraction (Fig. 2b). Suitable openings have been made in the lower part of the cabinet to suck the outside air, which is then withdrawn at the top by a suitable fan. The cabinet has been also

equipped with a H₂ gas detector to control if the atmosphere is able to explode. In this way, the area classified as dangerous has been limited inside the cabinet and has been considered as zone 2, i.e. a place in which an explosive atmosphere consisting of a mixture with air of dangerous substances in the form of gas, vapour or mist is not likely to occur in normal operation but, if it does occur, will persist for a short period only (ISO 22734-1:2008; Directive 94/9/EC).

Conclusions

The hazards assessment connected to the employment of the power system within the agricultural environment and executed through the HAZOP methodology has been very complicated due to its complexity but it is essential for the farmers' safety. The electrolyzer is the heart of this plant and it requires remarkable attention during its operation. The management of the products of the electrolysis process also involves forethought and trained operators. From the safety point of view the electrolyzer unit has been equipped with devices able to highlight the malfunctions before they cause damages to the operators and break off the process of hydrogen production. But the risk analysis of the power system is in progress because technical operations are being carried out for enhancing the plant functionality, making it more suitable to the designed task of supplying electrically the greenhouse heating system during cold periods.

Acknowledgements

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Figure 1. Plant external layout

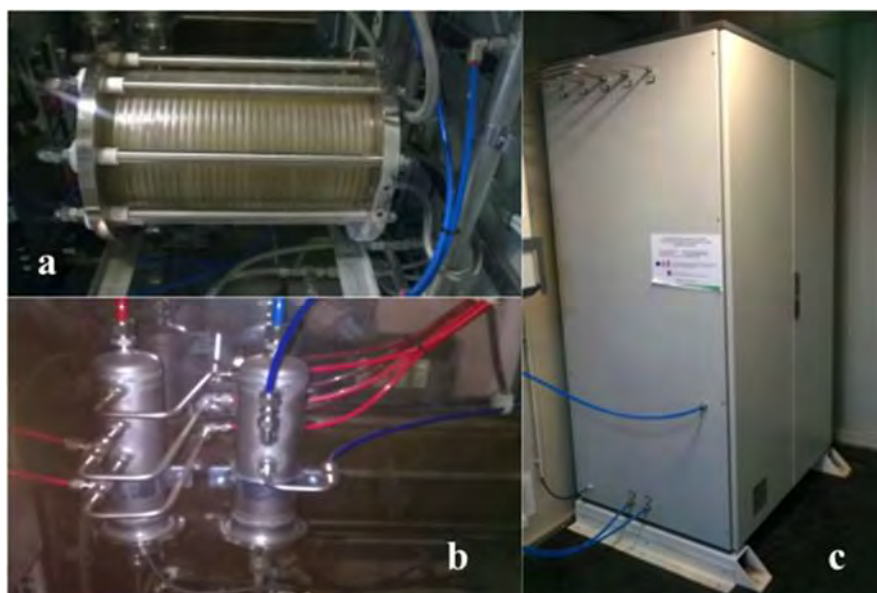


Figure 2. a. electrolyzer; b. analyser of oxygen and hydrogen; c. cabinet

TOPIC 7

“ROPS”

ROPS Design and Testing for Rigid and Foldable Structures

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Abstract

While Roll-over Protective Structures (ROPS) are prevalent on agricultural tractors in the United States, an estimated 1.6 million tractors are still not equipped with ROPS. Many of these tractors do not have ROPS commercially available although they were originally designed to support a ROPS. To meet this need, a computer-based ROPS design program was developed to quickly develop ROPS designs based on tractor weights and dimensions. The final product from the program is the ROPS design drawings with specifications that can be used to construct the ROPS. The constructed ROPS would then need to be tested to assure it meet the appropriate ROPS standard. Two ROPS designed with the program successfully passed the SAE J2194 static longitudinal, transverse and vertical tests.

Many ROPS being sold on new tractors use a foldable ROPS design. These ROPS are effective when the ROPS is raised and locked in place. But raising and lowering ROPS is a tedious and strenuous task, and many times ROPS are left down during tractor operations. Fatality reports are showing that operators are dying when tractor upsets are occurring with the mounted ROPS folded down. In one study the fatalities from tractor overturns with foldable ROPS down were 50% of the total tractor overturn fatalities examined. New OECD TAD/CA/WD(2014)8/REV1 defines the maximum forces to manually actuate a foldable ROPS. Forces measured on existing foldable ROPS far exceed those stated maximums. A simple mechanical foldable ROPS lift assist can ease in the raising and lowering of ROPS. A summary of foldable ROPS forces and the benefits of the ROPS lift assist will be presented.

Keywords: ROPS, Foldable, OECD

Evaluation of the stability of an articulated farm tractor using mounted implements on hillsides

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Abstract

When introducing a new farm tractor in the market, manufacturers undergo a tight homologation path under the supervision of the OECD centres technicians. Two of the most requested tests, although not mandatory for the commercialization of a tractor, are the individuation of the centre-of-gravity and of the lateral rollover angle on a tilting platform. The results of these tests are very interesting for the technical characterization of a vehicle but still far from its real working conditions, even if the tilting platform test forecasts, for example, the presence of fuel in the tank and the use of some weights to simulate the driver. Indeed, in this last test, no mounted implement (or equivalent mass) is connected to the tractor, hence limiting a lot the use of the results of the described tests.

Therefore, a numeric stability simulator was developed to overcome this problem, thus managing the variety of the possible implements to be connected to a tractor and giving the farmers effective indications concerning their vehicles' safety while working on hillsides. This simulator, based on a Newtonian approach, is able to compute the stability of a vehicle formed by a tractor and an implement.

It was used to verify the possibility of safety using some common mounted implements with a compact wheeled articulated tractor, specifically designed to work within terraced orchards/vineyards, common in mountain areas. This tractor was chosen because of its particular architecture: it gives the tractor a higher agility and a shorter turning radius than conventional tractors with the same dimensions, but also a very different stability behaviour, maybe not completely predictable in all situations by inexperienced drivers.

Keywords: Numerical Stability Simulator, Tractor + Implement Stability, Articulated Farm Tractor.

Introduction

The search for higher and higher safety and health conditions of agricultural workers is always a very important topic for manufacturers, engineers and scientists dealing with farm machines, having significant repercussions also for the whole society (Cecchini et al., 2013; Cividino et al., 2014; Cividino, Gubiani, Pergher, Dell'Antonia, & Maroncelli, 2013; Monarca et al., 2009). In particular, agricultural vehicles working on hillsides can easily reach critical conditions from the point of view of their stability (Gravalos et al., 2011; Hunter, 1993; Mazzetto, Bietresato, Gasparetto, & Vidoni, 2013; Mazzetto, Bietresato, & Vidoni, 2013; Previati, Gobbi, & Mastinu, 2014; Vidoni, Bietresato, Gasparetto, & Mazzetto, 2015) so one of the most interesting challenges is *predicting the possible rollover of a vehicle*, thus preventing the damages and the risks caused by an eventual overturning. For this reason, the mechanization of side-slope activities (Longo, Pennisi, Bonsignore, Schillaci, & Muscato,

2013) and, in general, the dynamic behaviour of off-road vehicles has been studying since the eighties and it is responsible for the continuous work of improvement which can be seen on the machines (e.g., the lowering of the centre of gravity or the introduction of active and passive safety systems).

The presence of an implement or a trailer connected to the tractor, is one of the most common causes of rollover on hill-sides especially if the vehicle is doing specific manoeuvres (e.g., tight turnings): the implement alters considerably the static and dynamic behaviour of the whole vehicle (tractor + implement/trailer) with respect to the behaviour of the same tractor alone (Ji-hua, Jin-liang, & Yan, 2011; Karkee & Steward, 2010; Popescu & Sutru, 2009). So, a tractor that is normally stable on a specific sloping ground could reach critical conditions if equipped with an implement.

Actual OECD homologation tests include only the search for the spatial position of the tractor's centre of gravity (even if with fuel in the tank and the some weights to simulate the driver). As a series of OECD-like experimental tests on the tractor connected with some specific implements could not be exhaustive of the whole market offer of the implements' makers, we proposed to integrate the OECD experimental results (performed on the tractor alone) with an ad-hoc developed numerical simulator. This tool, using a quasi-static Newtonian approach (Baker & Guzzomi, 2013; Guzzomi, 2012; Mazzetto, Bietresato, & Vidoni, 2013; Vidoni et al., 2015), is able to calculate the position of the centre of mass and the rollover angle of the vehicle “tractor + implement” with any implement and, therefore, to give an indication of the limit slope for safety operating with the tractor. More in detail, it quantifies the attitude of a vehicle “tractor + implement” to be stable in several slope and angular conditions by using a single number, the *Roll Stability Index (RSI)*, in a way similar to (Yisa, Terao, Noguchi, & Kubota, 1998) and (Liu & Ayers, 1999).

In particular, this approach has been used here to inquiry the stability performance of *articulated farm tractors*, i.e. wheeled agricultural tractors having a central joint used for steering (Mazzetto, Bietresato, Bisaglia, Vidoni, & Weger, 2013; Mazzetto, Gallo, Vidoni, Bisaglia, & Calcante, 2012; Mazzetto, Gallo, Vidoni, & Bisaglia, 2013). These tractors have a higher agility and a lower turning radius than conventional tractors with the same dimensions, but, due to the particular architecture, their supporting polygon varies with the steering angle (Vidoni et al., 2015) and their behaviour could be difficultly predictable by inexperienced drivers.

Aims of this work

The aim of this work is to propose a methodological approach for evaluating a priori the stability of an agricultural vehicle operating on hillsides and equipped with different (mounted) implements, with known dimensions and masses. This approach integrates effectively a numerical simulator with the results of the OECD tests.

We also want to show the capabilities of the numerical simulator, part of the approach, when it is applied to inquiry the stability of an articulated farm tractor.

Materials and methods

The studied articulated tractor

The agricultural tractor studied in this work is a very compact 4-wheel drive articulated tractor, designed to operate as an implement-carrier within vineyards and orchards placed on steep hillsides (Figure 8, Table 7). It presents a series of interesting features: a narrow track, a low centre of gravity (CoG), a central articulation (or “joint”) of the chassis, the engine in the

front part, a loading platform in the rear part, a reversible driving seat immediately above the motor, a hydrostatic transmission.

The central joint has two degrees of freedom (DoFs): one hydraulically-operated through a joystick (the *jaw*, used for making the tractor steer), the other passive (the *roll*, to allow the vehicle complying with the terrain). Hence, this vehicle changes its travelling direction by modifying the angle between the two parts composing the chassis: the consequent angulation of the axles individuates a centre of rotation for the vehicle on the horizontal plane, in accordance with the classical kinematics (Vidoni et al., 2015).

This architecture gives the tractor a superior flexibility of use and the driver a very high visibility from his seat but this steering modality, affecting the baseline dimensions and shape, the presence of a passive DoF of the joint and the equipment of the tractor with an implement in its front or rear part, modifying the balance, could be potentially critical for the vehicle's stability.

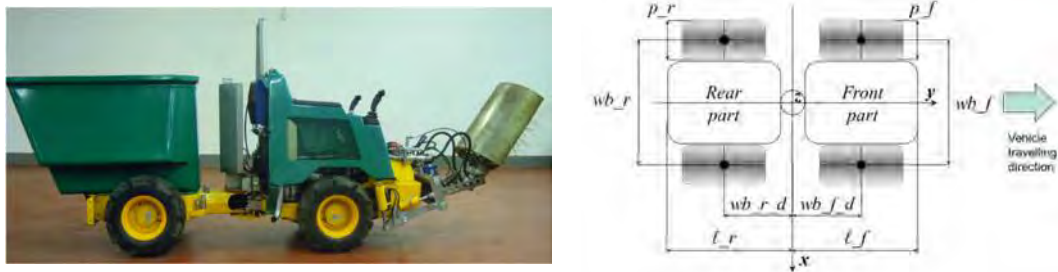


Figure 8. (left) Overview of one of the first prototypes equipped with a front-coupled mower and a rear dumper; (right) Main dimensions of an articulated wheeled tractor and used frame of reference (z axis is perpendicular to the supporting plane of the tractor and is pointing towards the observer).

Table 7. Main geometrical and mechanical parameters referred to the articulated tractor (f: front part; r: rear part; for other abbreviations refer to Figure 8).

Quantity	Value
$CoG\_f\ position\ (^{\circ})$	[0.011, 0.621, 0.270] m
$CoG\_r\ position\ (^{\circ})$	[0.000, -0.618, 0.159] m; [0.000, -0.500, 0.000]** m
$\ell_f; \ell_r$	1.226 m; 0.923 m
$wb_f; wb_r$	0.710 m; 0.685 m
$wb_{fd}; wb_{rd}$	0.669 m; 0.669 m
$p_f; p_r$	0.200 m; 0.200 m
Joint height	0.280 m
Mass(es)	650 (f) + 344*** (r) kg
Maximum steering angle	110° between the two tractor halves

(*) coordinates referred to a local coordinate system, placed as drawn in Figure 1; (**) without any ballast on the rear end; (***) when no implement is placed on the rear end (149 kg), a ballast (195 kg) is used.

The stability simulator

A Matlab® simulator implements the classical steering kinematics of a vehicle (Genta, 1997), allowing the user to insert the position of the implement's CoG and calculating the position of the CoG of the whole vehicle with respect to the stability baselines. Thanks to this simulator, it is possible to inquiry the different stability conditions for a tractor equipped with any implement and working on sloping terrains.

In particular, the positions of the wheels can be computed while the vehicle travels

along a circumference with a set radius on a perfectly smooth inclined plane, neglecting the friction contributes in the advancement direction and the inertial terms (quasi-static approach).

The stability critical angle (*Type II stability*) is searched with respect to the slope and the angular position of the vehicle on the circumference, supposing that the vehicle never slips along the plane and its wheels stay always in contact with the plane.

If d is the distance of the projection CoG* of the CoG from the tractor line of symmetry along the maximum slope direction and d_{-l} the critical stability condition, i.e. the distance corresponding to the scenario in which the CoG projection is on the baseline border (*Type II instability*; Figure 9), the *Roll Stability Index (RSI)* is defined as follows (Liu & Ayers, 1999):

$$RSI = \left(1 - \frac{d}{d_{-l}}\right) \cdot 100 \quad \text{with} \quad \begin{cases} RSI \in]0;100] \Leftrightarrow d \in [0; d_{-l}[: \text{stable configuration} \\ RSI = 0 \Leftrightarrow d = d_{-l} : \text{incipient overturning} \\ RSI < 0 \Leftrightarrow d > d_{-l} : \text{unstable configuration} \end{cases} \quad (1)$$

The instability of each part (*Type I stability*) is also evaluated by checking if the projection of the front and rear centres of mass fall inside or outside the proper stability triangle (Baker & Guzzomi, 2013; Guzzomi, 2012; Vidoni et al., 2015).

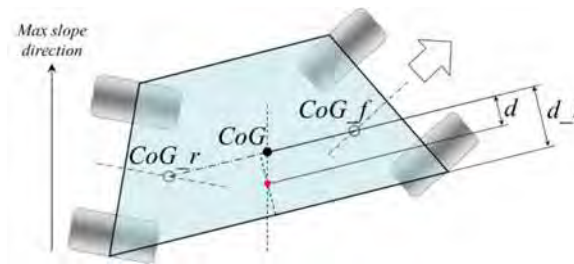


Figure 9. Top view of an articulated tractor while turning; in evidence: the positions of the CoGs on a perfectly horizontal ground (hollow/solid black points), the new position of the CoG projection along a line parallel to the max slope direction (solid red point, indicated as CoG*), the distances used for the calculation of the RSI and the support polygon of the vehicle (light blue).

The proposed approach

The prediction of the minimum value of the RSI or, in general, the forecasting of the equilibrium conditions of a generic tractor equipped with an implement (with known mass and CoG position) can be done by following the four-step approach presented here:

1. Experimental positioning of the centre-of-mass of a tractor in accordance with the current EU norms;
2. Input in the simulator of the data concerning the tractor (geometrical and mechanical parameters), the implement (mass and position of the CoG with respect to the linkage system) and the scenario to be simulated (slope and circumference radius to be travelled, also called “turning radius”);
3. Calculation of the CoG of the whole vehicle in a perfectly horizontal plane and of the stability conditions (*Type I and II stability*) of the tractor in each angular position on a sloping ground;
4. Generation of graphical and numerical outputs.

While step 1 is performed once per tractor, steps 2-4 can be repeated many times, i.e. once per implement and per scenario (slope, turning radius) to be inquired. To give an effective aid to the farmers, the values of the slopes and turning radii to be inquired should be close or equal to the values which farmers can experiment within their fields.

Inquired scenarios

With regards to the presented articulated tractor, a generic mounted implement can be coupled to it according to one of the following schemes:

- implement *mounted frontally and operating centrally* with respect to the tractor’s longitudinal axis; the connection of the implement to the tractor is made through a properly-designed front lifter equipping the tractor;
- implement *mounted frontally and operating laterally* (i.e., not centrally) with respect to the tractor’s longitudinal axis; the implement is at the external/internal side of the turn; the connection of the implement to the tractor is made through a properly-designed front lifter equipping the tractor;
- implement *positioned directly on the tractor’s rear end* (i.e., on the plane above the rear axle).

The simulator can easily manage all the above-described situations and calculate the RSI value and the Type-I stability of the vehicle: every implement is described only in terms of mass M and CoG coordinates (x_G , y_G , z_G) in the tractor’s frame of reference.

Therefore, we verified the possibility to safely use several different commercial implements on this tractor (**Table 8**); their dimensions, CoG positions and masses were taken from the respective catalogues. The hydraulic-driven implements were chosen by matching the minimum power requirements, indicated by the manufacturers, with the maximum available power of the tractor (26 kW at 3600 rpm).

Table 8. Different implements inquired in this study; observe that L is the distance implement’s CoG from the front part of the tractor (positive: implement in front of the tractor) or from the rear axle (positive: the implement’s CoG behind the rear axle), B is the distance CoG – tractor’s longitudinal axis (positive if in the same direction of the x axis).

Implement		Parameter			
Type	Front / rear	Implement mass (M)	Height of the implement CoG from the supporting plane (H)	Distance of the implement CoG from the front part of the tractor or from the rear axle (L)	Distance between the implement CoG and the tractor longitudinal axis (B)
		kg	m	m	m
Sprayer equipment (*)	R	290	0.338	0.295 (from the rear axle)	0.00
Dumper carrying apples(*)	R	328	0.430	0.243 (from the rear axle)	0.00
Dumper carrying sand (*)	R	770	0.430	0.243 (from the rear axle)	0.00
Front shredder/fodder cutter	F	165	0.280	0.500 (from the front part)	0.00
	F	190	0.280	0.500 (from the front part)	0.00
	F	230	0.280	0.500 (from the front part)	0.00
Front vine-shoot shredder	F	250	0.280	0.500 (from the front part)	0.00
	F	275	0.280	0.500 (from the front part)	0.00

Implement		Parameter			
Type	Front / rear	Implement mass (M)	Height of the implement CoG from the supporting plane (H)	Distance of the implement CoG from the front part of the tractor or from the rear axle (L)	Distance between the implement CoG and the tractor longitudinal axis (B)
		kg	m	m	m
	F	300	0.280	0.500 (from the front part)	0.00
	F	320	0.280	0.500 (from the front part)	0.00
	F	335	0.280	0.500 (from the front part)	0.00
Lateral shredder/fodder cutter	F	245	0.280	1.050 (from the front part)	±1.05
	F	265	0.280	1.050 (from the front part)	±1.15
	F	285	0.280	1.050 (from the front part)	±1.25
Shoot remover	F	55	0.280	0.500 (from the front part)	±0.50
Bilateral shoot remover	F	110	0.280	0.500 (from the front part)	±1.00
Sickle bar	F	140	1.260	0.500 (from the front part)	±0.50
Double sickle bar	F	180	1.260	0.500 (from the front part)	±0.50

* This implement was considered at its maximum load capacity (i.e., the sprayer was supposed to be filled up with water, the dumper with apples or sand) and to be symmetrical with respect to the tractor's longitudinal axis. Mass values are referred to the implement's frame and the payload together.

Results

The effect of each of the listed implements on the global stability of the vehicle has been inquired in correspondence with two ground slopes (30°, 45°) and turning radii (2 m or infinite, i.e. when the tractor is travelling on a straight trajectory). Results are reported in Table 9.

Table 9. Assessment of the stability of the whole vehicle (tractor + implement); two numbers will be reported for lateral implements: the first/second one refers to an implement located at the external/internal side of the turn (i.e. with B negative or positive, respectively).

Implement	Minimum RSI				Type-I st.	
	$\alpha=30^\circ$		$\alpha=45^\circ$		$\alpha=30^\circ$	$\alpha=45^\circ$
	R=2	R=INF	R=2	R=INF	R=2 or INF	
Sprayer equipment	37	58	8	36	1.0	1.0
Dumper carrying apples	30	51	-6	21	1.0	1.0
Dumper carrying sand	16	45	-31	4	1.0	1.0
Front shredder/ fodder cutter	71	82	56	69	1.0	1.0
	70	83	56	70	1.0	1.0
	70	83	55	71	1.0	1.0
Front vine-shoot shredder	69	83	55	71	1.0	1.0
	69	83	55	72	1.0	1.0
	68	83	55	72	1.0	1.0
	67	83	55	73	1.0	1.0
	67	83	55	73	1.0	1.0
Lateral shredder/ fodder cutter	39/74	57/61	28/63	48/52	0.9/1.0	0.7/0.7
	34/71	53/57	23/61	44/48	0.8/1.0	0.6/0.7
	29/68	48/52	19/59	40/44	0.7/0.9	0.5/0.6
Shoot remover	73/78	81/83	53/59	63/65	1.0/1.0	1.0/1.0
Bilateral shoot remover	62/78	73/76	45/62	57/61	1.0/1.0	0.8/0.9

Implement	Minimum RSI				Type-I st.	
	$\alpha=30^\circ$		$\alpha=45^\circ$		$\alpha=30^\circ$	$\alpha=45^\circ$
	R=2	R=INF	R=2	R=INF	R=2 or INF	
Sickle bar	72/85	81/85	63/77	75/78	0.9/1.0	1.0/1.0
Double sickle bar	72/88	82/85	65/82	78/80	1.0/1.0	1.0/1.0

Observing the results in Table 9, it is possible to deduce some general trends; in particular, the minimum RSI value decreases:

- with the increase of the implement's mass M , which has the effect to move the global CoG of the vehicle towards the implement's CoG;
- with the increase of the distance L between the implement's CoG and the front part of the tractor (or the rear axle of the tractor), indicating a greater straddle of the implement with regards to the tractor chassis;
- with the increase of the distance B (between the implement's CoG and the tractor's longitudinal axis), shifting laterally the global CoG from the longitudinal axis;
- with the increase of the height H of the implement's CoG from the ground, having the effect to lift up the global CoG.

The implements to be mounted in the front part of the tractor result having a stabilizing effect on the vehicle, since they have very low centres of gravity; vice versa for the implements to be mounted on the tractor's rear end. In particular, if the tractor has the dumper full of sand or apples, Type-II rollover will surely occur when turning on a 45° -slope hillside ($RSI < 0$). The same turning manoeuvre with the dumper full of sand is quite dangerous even at 30° (RSI very low and next to 0) so a particular care should be taken, especially on harsh terrains.

Looking at the Type-I stability, overturn can occur (e.g. the index is index different from 1.0) when turning on a 45° -slope ground with a 285-kg lateral shredder at the external side of the turn and when using a lateral shredder with a mass greater than 245 kg on a 45° -slope ground, whichever the position of the implement (external/internal side of the turn). Therefore, the driver must absolutely not use that implement in the described conditions.

Conclusions

This work shows a mixed experimental-numerical approach for evaluating the stability of agricultural vehicles equipped with different mounted implements and operating on a sloping ground. In particular, this approach has been applied to study the stability performance of a 4-wheel drive articulated tractor, very agile and having many points of innovation.

The described approach has proved to be able to raise effectively the safety of the tractor driver because it has allowed individuating preventively some possible dangerous situations. Thanks to it, we can suggest to avoid using two specific implements (e.g., the dumper and the lateral shredder on 45° hillsides) without having performed any experimental test on the complete vehicle (tractor+implement).

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Performance evaluation of a commercial tractor stability control system

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Abstract

The study takes origin from the increasing development of aftermarket devices to evaluate tractor rollover risk on the basis of dynamic parameters detected by sensors.

Aim of the research was a tractors rollover risk assessment in normal field operation, using a commercial device to evaluate the activities at higher rollover risk for the agricultural operators. Five tractors used in the experimental farm of the Bologna University were monitored in the 2013 year. Each tractor was equipped with a stability control system based on a hardware multisensory device, a software risk index algorithm and an integrated position information system for tractor localizing. The detected parameters and tractors position were accessible via a dedicated web site. Fourteen transceivers were connected to implements for recognition when coupled to the tractor.

Preliminary tests demonstrated that the tilt sensors used in the device did not provide high performance when the tractors were subjected to sudden operative changes. The risk assessment, in fact, was based on a quasi-static evaluation of stability conditions.

On the other hand the device seemed suitable to monitor dangerous practices in the normal operation of the tractor; the system could represent a good tool to educate unskilled drivers, becoming an acceptable compromise between safety evaluation and farm management.

Among the monitored operations the liquid manure spreading and the round baling were the ones at highest risk, while plough and rotary harrow were considered as tractor stabilizers.

Keywords: Rollover, Safety, ROPS

Introduction

In the field of work safety in agriculture tractor rollover is matter of concern because it represents not only the most frequent injury (Mayrhofer et al., 2014), but also the leading cause of death (Abubakar et al., 2010; Arana et al., 2010; Reynolds and Groves, 2000). The great versatility of use, the environment changes and the long service life make the tractor a highly dangerous machinery. In the years a growing operator safety awareness led to promote stringent regulatory requirements, to define test procedures on the stability of tractors and machinery (Gravalos et al., 2011) and to assess rollover risk (Fagnoli et al., 2010).

Laboratory tests, under controlled conditions, allow using simplified models capable to predict tractor stability and non-continuous rolling behavior (OECD Code 6, 2015). Nonetheless, in field conditions a greater number of factors are involved. Tractor stability in fact is influenced not only by geometric parameters such as the position of the center of gravity, wheelbase and track, but also by dynamic characteristics, as forward speed, tractor-implement linkage, steering angle rate etc.

Moreover the contribution of factors related to the environment and land morphology, and those depending on the operator, such as skill, reaction time, experience and risk perception, affect the rollover of tractors and machinery.

Due to the complexity of overturning dynamics, the traditional approach has been to consider highly unseemly to avoid tractor rollover, orienting instead the efforts to minimise

the effects of the accident on the operator through the adoption of Roll Over Protective Structure (ROPS) (Moerberg, 1973).

Such structures have greatly reduced the number of fatal accidents (Springfieldt, 1998; Röthmeier, 2013). However it has been proven that seat belts are a necessary complement to the protection provided by ROPS (Molari and Rondelli, 2007; Myers and Pana-Cryan, 2000).

A driver assistance device, alerting the operator in critical conditions for the stability of the tractor, may contribute to improve the driver perception of risk increasing the prevention of accidents by correcting inappropriate behaviors. These driver assistance devices, providing signals to alert the operator, have been developed by several researchers in the world (Murphy et al., 1985; Spencer and Owen, 1981).

Instrumentation for tractor pitch and roll angle measurement was tested at a constant speed on uniform gradient test tracks to evaluate the linearity of the acquisition system with good results (Freeland, 1990).

A system composed of uniaxial accelerometers, a gyroscope and a micro-controller was designed by Greene and Trent as a predictive tool of tipping (Greene and Trent, 2002).

Nichol et al. (2005) developed a device based on low-cost sensors and a microcomputer capable of providing a brief time history of roll angle to the operator. The mathematical model for the assessment of potential rollover situation was simplified and quasi-static and provides an evaluation of the stability in real time situations.

Recently, an interesting application for smartphones has been developed by Liu and Koc (2013) using integrated sensors with a calculation model derived by the model developed in 1999 by Liu and Ayers for the prediction of potential tractor tipping situations (Liu and Ayers, 1999).

These devices, although oriented to a possible industrial development, were mainly research tools; however nowadays commercial systems begin to be on the market. Therefore evaluating their performance could be of valuable importance. In fact a commercial product has properly to balance reliability and simplicity in use, being designed with components allowing a simple operation in field while providing an acceptable stability risk assessment.

The main aim of the study was to evaluate the performance of a commercial device designed for monitoring tractor stability in field conditions in order to characterize the reliability of the values of the dynamic parameters detected by the instrument and to verify the effectiveness in improving the risk perception of the operator. A monitoring activity was carried out on five tractors operating in the experimental farm of the University of Bologna to identify the most risky conditions for tractor rollover.

Materials and methods

A commercial stability control system for dynamic assessment of tractor stability conditions in real time was tested in normal field operation. Parameters influencing the risk of rollover were monitored.

The device was composed of hardware, software and an integrated information system (Rondelli et al., 2013). The localization of the tractor and the data detected by the sensors were stored in a dedicated database.

The hardware of the system consists of a main unit, installed on the tractor (Fig. 1a), a display, located into the tractor cabin to alert the operator with a risk signal when approaching the stability limit (Fig. 2a) and wireless transceivers placed on the implement linked to the tractor to allow for identification (Fig. 1b). The low cost and compact sensors integrated in the main unit were:

- Dual axis accelerometer as tilt sensor to measure the inclination angle.

- Tri-axial accelerometer to validate the signals from the bi-axial accelerometer, to confirm tractor overturn.
- Gyroscope to assess tractor steering angle rate.
- GPS for tractor geographical localization.
- GSM/GPSR for data transmission.

Data processed by the system, through a dedicated algorithm, provided a stability risk index based on a simplified quasi-static model. Geometric parameters of the tractor-implement system (mass and overall center of gravity of the system and wheelbase and track of the tractor) and the values detected by the sensors during the operation (speed, pitch and roll angles, steering angle rate) were computed in the model.

The risk index was expressed as percent. Absence of risk conditions had a corresponding visual signal on the display consisting of concentric green circles, 70% rollover estimated risk was shown as yellow circles then, overcoming the 95% threshold of estimated risk, the color became red and an audio signal was added.

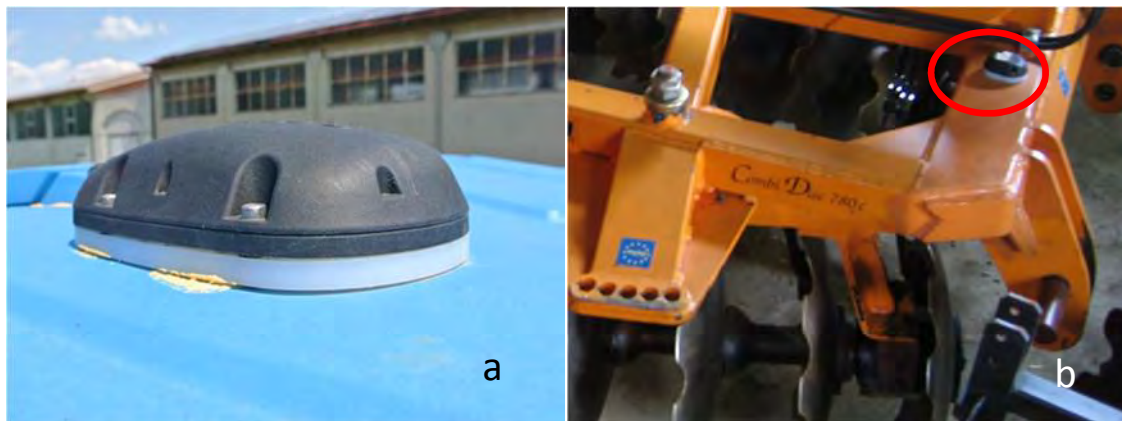


Figure 1. Main unit located on the tractor roof (a); transceiver on the implement (b)

Preliminary tests

Preliminary tests were carried out on an agricultural tractor to evaluate the performance of the stability control system in static and dynamic conditions.

Static tests were carried out on an inclined plane in concrete. The tractor equipped with the main unit was placed on the plane in different positions to evaluate pitch and roll angles. During the test a digital level was used to compare the angle measurements. In the tests the tractor reached values above the threshold limit for the alarm signal. Figure 2b shows pitch and roll angles simultaneously detected and the visual alarm represented by the concentric yellow circles.

The dynamic tests were carried out in controlled field conditions at the experimental farm of the University of Bologna. The real time values of pitch and roll angles were compared with those recorded by the digital level. Values of the forward speed detected on the display were compared to those simultaneously measured by a GPS speed sensor in use at the Test Station of the University of Bologna.



Figure 2. Tractor on the inclined plane during the static test (a); display of the system visualizing the alarm signal (b)

The tractor was driven forward a farm road at speed of 10.0 km h^{-1} on a hillside, with a longitudinal gradient of 8 degrees, to check the pitch angle.



Figure 3. Test in field to evaluate the roll angle (a) and the steering condition (b)

A 20 m track with a crosswise slope of 11 degrees and no longitudinal slope was used to verify the roll angle. The test was carried out at 2.3 km h^{-1} and 10.0 km h^{-1} forward speeds (Fig. 3a).

An additional test was carried out driving the tractor on a 10 m diameter circular track at a constant speed of 4.6 km h^{-1} (Fig. 3b). The track was marked on a grass area with a slope of 7 degrees.

Field tests

Five tractors operating in the experimental farm of the University of Bologna were monitored in 2013 during an entire growing season (Table 1). Tractors worked in flat and hilly areas. Transceivers were installed on fourteen implements coupled to the monitored tractors. The

implements monitored were: rotary mower, tedder, liquid manure spreader, two round balers, two rotary harrows, harrow, subsoiler, mower conditioner, plough, grubber, liquid sprayer, flail mower.

Each tractor was fitted with the main monitoring unit; up to six implements equipped with transceivers were allowed per tractor. The most significant and frequent combinations were then selected providing a comprehensive evaluation of the activities performed in the farm.

To evaluate the effectiveness of the stability control system in improving the operator risk perception, each tractor driver had to complete per day a survey form explaining his perception about the operating conditions.

Table 1. Tractors monitored in seasonal stability evaluation

Tractor power (kW)	Working Area	Main field operations
107	hill	harrowing, baling, liquid manure spreading
74	hill	baling, liquid manure spreading, mowing
200	hill and plain	plowing
103	plain	harrowing, subsoiling, baling
63	plain	mowing, hay making

Results and discussion

In the preliminary static tests the real time values detected by the main unit and shown on the display showed a slight difference (± 1 degree) with respect to those measured by the digital level. Data recorded on the dedicated database were perfectly coincident with the displayed values. High values of pitch and roll angles produced visual alarms on the display.

Table 2 shows the results of the preliminary dynamic tests comparing the values of the main unit with those obtained by the GPS speed sensor and the digital level.

Concerning the pitch angle, data detected by the stability control device had a difference of ± 1 degree with respect to those recorded by the digital level.

A significant difference of performance was evident in the assessment of the roll angle at the two speeds tested. The values of the speeds shown on the display, 2.3 and 10.0 km h⁻¹, were fairly consistent with those reported by the GPS speed sensor, respectively 2.8 and 10.6 km h⁻¹, but at the slow speed the measure of the roll angle was immediately displayed, about 9 degrees, while at the higher speed the roll angle was shown consistently only after the tractor travelled half of the test track, therefore with a noticeable delay.

In the test on the 10 m diameter circular track, with the tractor travelling at the speed of 4.6 km h⁻¹, corresponding to 5 km h⁻¹ for the GPS speed sensor, the main unit did not consistently detect the pitch and roll angles, probably due to the continuous and fast change of these parameters.

As a general consideration the device in the dynamic tests with steady conditions of stability showed an acceptable performance, while the fast variation in the conditions of stability evidenced the failure of the system. Since the device was a commercial system no in depth details were available on the hardware and overall architecture of software, therefore the main cause of the unsuitable performance was not identified.

Table 2. Parameters measured in the preliminary dynamic tests (mean values)

Track	Speed Main Unit (km h ⁻¹)	Speed GPS speed sensor (km h ⁻¹)	Pitch Angle Main Unit (degrees)	Roll Angle Main Unit (degrees)	Angle Digital Level (degrees)
Farm road	10.0	10.6	8	na	8
20 m track	2.3	2.8	-	9	11
20 m track	10.0	10.6	-	9*	11
Circular track	4.6	5.0	-	-	7

* Value provided by the stability control device with a delay of 3.6 s

A statistical analysis of the dynamic parameters recorded in the field operations during the growing season 2013 was carried out considering each tractor-implement system.

The operations carried out in the hilly area caused, as expected, a larger number of alarm signals. In figures 4 and 5, showing the most significant operations, the relative frequencies of the risk index were considered.

High frequencies at high values of risk index may not correspond to a high number of alarm signals if, for example, the implement was scarcely used. Indeed the analysis shows the level of risk of the implement with respect to the frequency of use.

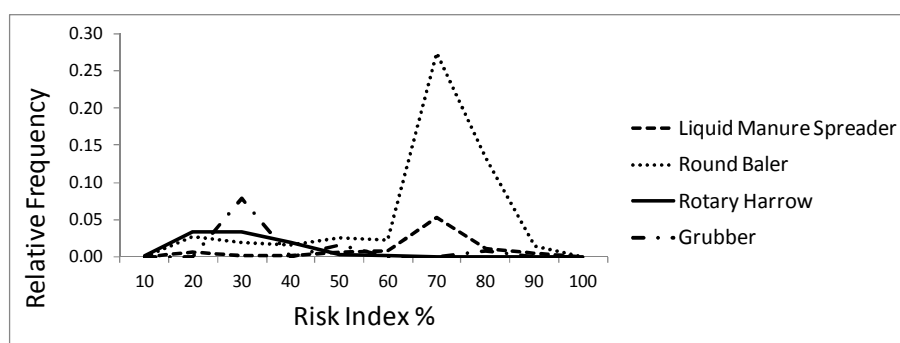


Figure 4. Frequency distribution of the risk values in the operations carried out in the hilly area (tractor 1)

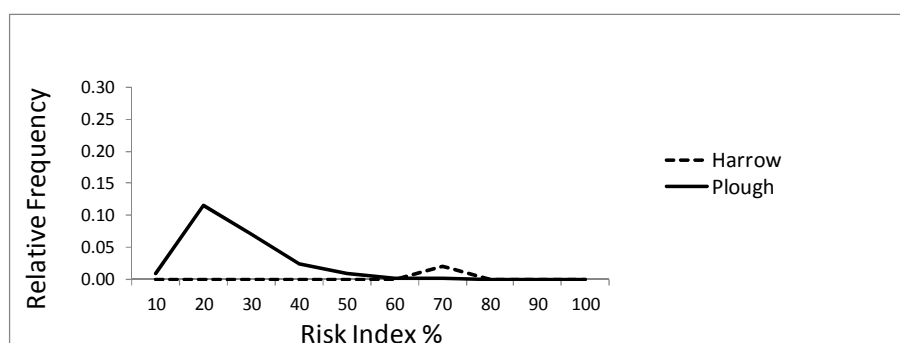


Figure 5. Frequency distribution of the risk values in the operations carried out in the hilly area (tractor 2)

Round baling and liquid manure spreading had frequency peaks at high levels of risk and, vice versa, plowing and rotary harrowing showed no alarm signals even if the system often detected high values of roll angle. The result probably has to be related to the risk index

defined by the calculation algorithm for the different machinery. Plough and rotary harrow were probably associated to a stabilization action of the implement-tractor system.

In field operations the operator was alerted too frequently, as resulted by the survey forms filled in by tractor drivers. This result has to be considered with attention because it is important to adjust the frequency of the alarm events to the real field conditions in order to avoid boring the operators and therefore a consequent underestimation of the risk.

Conclusions

Tests carried out on a commercial tractor driver assistance system allowed to evaluate the reliability of the values of the parameters detected by the sensors and to verify whether the system increased the operator risk perception.

The results obtained showed an acceptable performance of the system in steady conditions of stability. On the contrary the values detected in operations characterized by a fast change in the stability conditions, likely the ones leading to a rollover event, evidenced the failure of the device. The results seem consistent with the risk assessment calculated by the system, based on a quasi-static evaluation of the tractor stability.

The stability control device could be considered a good tool to educate inexperienced operators to increase awareness and perception of risk but the algorithm adopted for risk index calculation needs improvement.

The stability parameters recorded on the dedicated website allowed to perform statistical analysis of the tractor-implement system in real field conditions. Data could be of interest to better define the basis assumptions of mathematical models aimed to define risk indexes.

The values recorded in the seasonal monitoring at the experimental farm of the University of Bologna helped to identify the operations with a higher frequency of risk.

The system provided acceptable results if considered as a compromise between a farm machinery management tool and a device to train unskilled operators to improve rollover risk perception.

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Non-continuous rolling in modern narrow-track tractors

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Abstract

Tractor rollover is one of the most hazardous event for the operator. Roll-Over Protective Structure (ROPS) was introduced to protect operator passively. In the specific case of protective structures in front of the drivers and fitted on wheeled narrow-track agricultural tractors, ROPS has to avoid the non-continuous rolling in the event of lateral rollover. Mathematical Model is included in the preliminary tests of the standardised testing procedures issued by the Organisation for Economic Co-operation and Development in order to check non-continuous rolling behaviour in narrow-track wheeled agricultural tractors. Modern narrow-track tractors fitted with rubber-tracks are currently designed but the standardised calculation does not cover the rubber-track tractors. The aim of the evaluation was to analyse the lateral tractor rollover behaviour as affected by the replacement of the tyres with the rubber-tracks. In the tested tractor the fitment of rubber-tracks replacing the rear wheels showed to increase the tractor mass and to affect the position of Centre of Gravity causing a downward and rearward shift with respect to the equivalent wheeled tractor. The track-ground interaction was different compared to the tyre-ground one. Mainly, the behaviour of the rubber-track with respect to the tyre at the state of unstable equilibrium under full load caused the rotation of the tractor around the outer edge of the track.

Keywords: ROPS, Rollover, Stability, Rubber-Track.

Nomenclature

M	reference mass (kg)
B	minimum overall width of the tractor (m)
B_6	width of protective structure between the right and left points of impact (m)
m	weight of the pendulum block (2000 kg)
g	gravitational acceleration (9.81 m s^{-2})
F	crushing force (N)
H	height of fall of the pendulum block (mm)
E	energy input (J)
$A0$	non-continuous rolling model ground slope (34 deg)
ρ	non-continuous rolling model angle between the CoG and the point of unstable equilibrium (deg)
h	difference of CoG height (from initial position at the unstable equilibrium to first impact) (m)
d	distance between the rotation point and CoG (m)
ω	angular velocity (rad s^{-1})
PE	potential energy (J)
Abbreviations	
<i>CoG</i>	Centre of Gravity
<i>ROPS</i>	Roll-Over Protective Structure
<i>OECD</i>	Organisation for Economic Co-operation and Development

Introduction

Intense competition among manufacturers of agricultural narrow-track tractors caused innovative design solutions (Figure 1). The new design approach allowed the development of an agricultural machine suitable to many operations in the farm. The small size of these narrow-track tractors is suitable to modern orchards and vineyards with narrow inter-rows. On steep slope track-laying tractors (Figure 1b-1d), with a greater contact surface to the ground, allow a higher stability and adherence and are often preferred to the wheeled tractors (Figure 1a). However, the steel track does not allow speeds comparable to the tyre. The development in the design led to new narrow-track tractors to combine the advantages of tyre and track. These tractors are derived from the wheeled ones replacing tyres with tracks (Figure 1c).

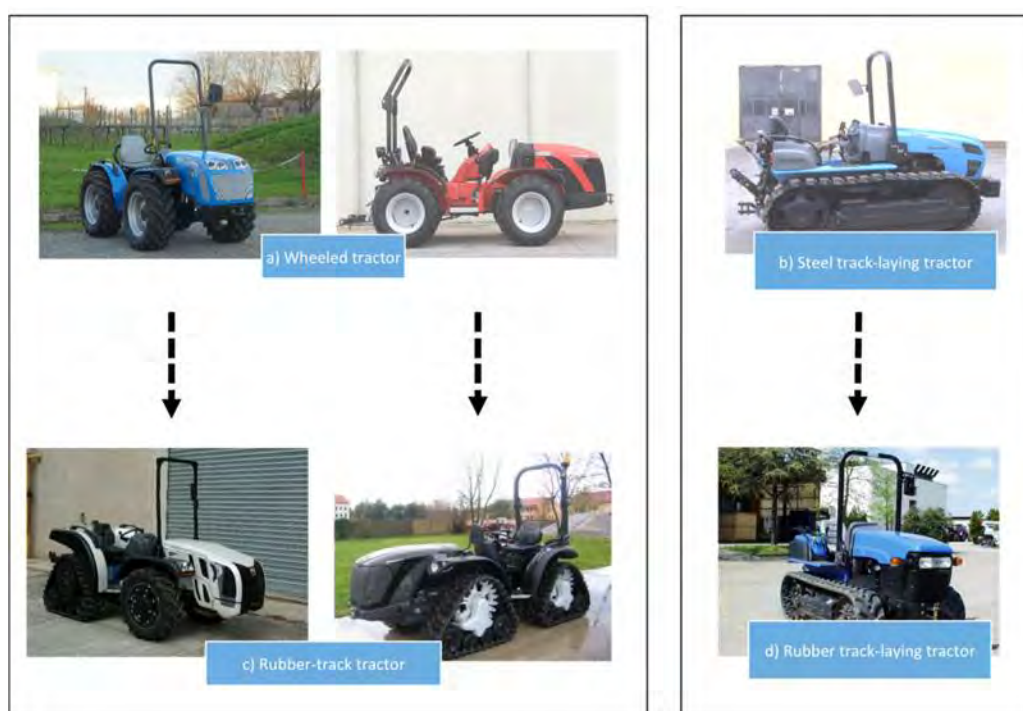


Figure 1. Narrow-track tractor types

The design approach has been to replace tyres with rubber-tracks on the rear axle or even in both axles (Figure 2). The rubber-track allows the tractor to have higher travelling speed with respect to the steel track-laying tractor and at the same time provides a traction performance higher than the wheeled tractor. Rubber-tracks are more comfortable than steel-tracks because of the lower noise and vibration levels. A negative aspect of the rubber-tracks is related to the tractor steering. To overcome the problem, the rubber-tracks on the front axle are fitted on articulated tractors in which the steering of the front part of the tractor is obtained through its central joint (Guzzomi & Rondelli, 2013). The variable conditions in tractor field operation (such as slopes, slippery surfaces, drainage ditches, etc.) introduce the risk of instability, potentially leading to tractor rollover. ROPS is the structure fitted on the tractor to minimize the risks to the driver in a rollover event during the normal tractor operation. The ROPS is characterized by the provision of a clearance zone large enough to protect the driver (OECD Codes, 2015).

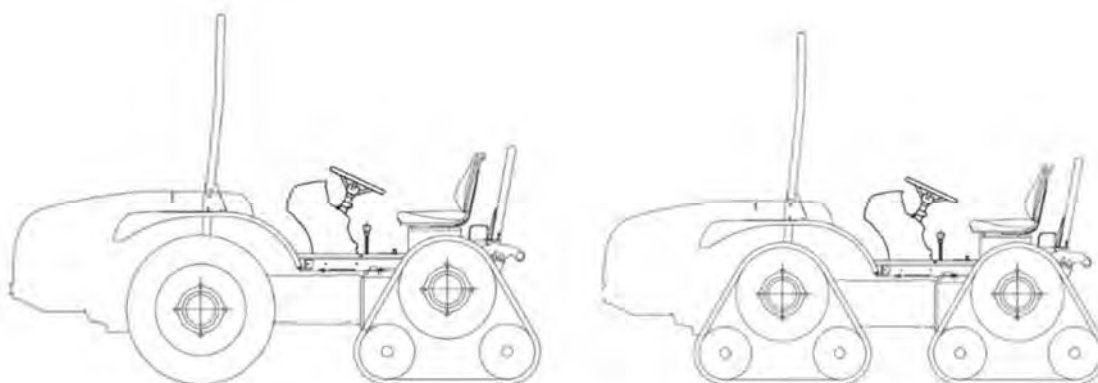


Figure 2. Design solutions of rubber-tracks fitted on narrow-track tractors

Before the widespread introduction of ROPS, tractor rollover caused severe injuries and fatalities (Chisholm, 1972; Moberg, 1964). Fortunately ROPS has long been recognised as an effective mean to greatly reducing the likelihood of operator injury in tractor overturning (Springfeldt, 1996). Over the last forty years, ROPS gave a major contribution to agricultural vehicle safety, even if it is worldwide accepted that it is impossible to protect the operator in all rollover instances. Consequently ROPS test criteria were issued to ensure tested ROPS providing an acceptable driver protection in tractor rollover occurring in normal operation. However, the testing criteria for front ROPS fitted on narrow-track tractors have been defined only for wheeled tractor (Chisholm, 1979a, 1979b, 1979c; OECD Code 6, 1990).

The effect on the safety provisions to replace tyres with tracks has to be evaluated.

ROPS testing procedure

Test procedures for narrow-track wheeled agricultural tractors defined by international standardisation organisations to evaluate the strength requirements of ROPS fitted in front of the driver are already available (87/402/EEC, 1987; ISO 12003-1, 2008; OECD Code 6, 1990). Unfortunately modern narrow-track agricultural tractors with rubber-tracks are not included in the field of application. A reduced clearance zone is provided for the front foldable ROPS (Figure 3) allowing the tractor to operate in narrow conditions such as orchards and vineyards. In reason of this reduced survival volume, the ROPS strength procedures are completed by two preliminary tests to verify the tractor behavior in case of a lateral rollover. The protective structure may only be subjected to the strength tests if both the Lateral Stability Test and the Non-Continuous Rolling Test have been satisfactorily completed. ROPS tests are performed with dynamic or static procedures. The sequence of strength tests for OECD Code 6 (Table 1) is as follows:

1. Impact (Dynamic test) or loading (Static test) at the rear of the structure;
2. Crushing at the rear of the structure (Dynamic or Static test);
3. Impact (Dynamic test) or loading (Static test) at the front of the structure;
4. Impact (Dynamic test) or loading (Static test) at the side of the structure;
5. Crushing at the front of the structure (Dynamic or Static test).

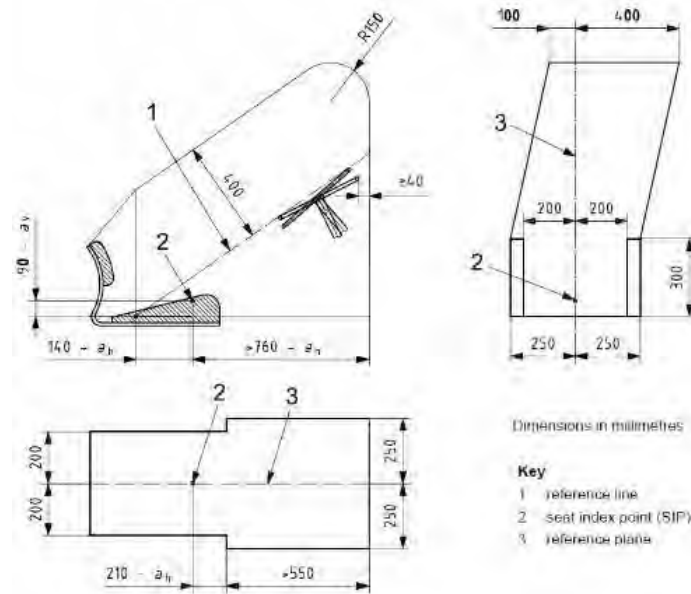


Figure 3. Reduced clearance zone according to the normalised testing procedures

Table 1. Sequence of codified tests

Sequence of strength tests	Dynamic procedure	Static procedure
Impact (Dynamic test) or loading (Static test) at the rear of the structure	$H = 25 + 0.07M$ if $M < 2000$ kg $H = 125 + 0.02M$ if $M > 2000$ kg	$E = 500 + 0.5M$
Crushing at the rear of the structure	$F = 20M$	
Impact (Dynamic test) or loading (Static test) at the front of the structure	$H = 25 + 0.07M$ if $M < 2000$ kg $H = 125 + 0.02M$ if $M > 2000$ kg	$E = 500 + 0.5M$
Impact (Dynamic test) or loading (Static test) at the side of the structure	$H = (25 + 0.2M) \left(\frac{B_6 + B}{2B} \right)$ if $M < 2000$ kg $H = (125 + 0.15M) \left(\frac{B_6 + B}{2B} \right)$ if $M > 2000$ kg	$E = 1.75M \left(\frac{B_6 + B}{2B} \right)$
Crushing at the front of the structure	$F = 20M$	

The tractor reference mass (M) is the mass, selected by the manufacturer to determine the energy and force to be reached during the strength tests. With respect to the dynamic test, M defines the fall height of the pendulum block (H); instead, in the static test it defines the energy that an actuator has to input to the structure (E). In both procedures, M defines also the value of the crushing force (F). The static procedure is satisfied when the required energy (E) is absorbed by the ROPS; while the impact dynamic procedure when the pendulum mass is pulled back so that the height of its center of gravity corresponds to the required height (H) and it is dropped to impact the ROPS. The preliminary lateral stability test has to verify the static stability of narrow-track tractors on a slope of 38 degrees. The non-continuous rolling test is intended to check whether a ROPS fitted to the tractor can satisfactorily prevent continuous rollover in the event of a lateral overturning on a slope with a gradient of 1 in 1.5

(34 degrees). The non-continuous rolling behaviour evaluation in Code 6 refers to a virtual method. Many theoretical and experimental studies were carried out in the seventies and eighties and the Mathematical Model able to simulate the behaviour of a wheeled tractor during a lateral overturning was developed (Schwanghart, 1984). This model takes into consideration specific critical boundary conditions and in 1990 was included into the OECD Code 6 (OECD Code 6, 1990). The replacement of tyres with tracks, however, introduces an additional parameter not considered in the original development of the model and affects the energy repartition at the ROPS-ground impact time, as studied by Chisholm (1979d).

The aim of the study was to analyse a narrow-track tractor fitted with front tyres and rear rubber-tracks in lateral stability test and non-continuous rolling behaviour calculation, as required by the standardised ROPS testing procedures.

Materials and methods

The behaviour of narrow-track tractors fitted with tyres (Figure 4, Tractor A) and rubber-tracks (Figure 4, Tractor B) was studied in terms of lateral stability and non-continuous rolling.



Tractor A



Tractor B

Figure 4. Tested tractors

The assessment refers to two narrow-track agricultural tractors fitted with a front foldable ROPS (Figure 4). The first tractor was fitted with tyres (Tractor A) and the second one with tyres on the front axle and rubber-tracks on the rear axle (Tractor B). The wheeled tractor was a tractor already on the market and typically tested according to the OECD Code 6. The Tractor B was a prototype derived from the wheeled tractor by substituting the rear tyres with rubber-tracks. The evaluation was carried out at the OECD Test Station of Bologna, Department of Agricultural and Food Sciences, University of Bologna. OECD Code 6 preliminary tests were carried out on both tractors.

Lateral stability test

The tractors were placed on a horizontal plane with the front tyres turned to full right lock and the heaviest axle tilted while measuring constantly the angle of inclination. The test was stopped at the unstable equilibrium time of the tractor. The test was repeated with the front tyres turned to full left lock. The requirement for lateral stability is the tractor resting in a condition of unstable equilibrium at an angle of inclination of at least 38 degrees on the wheels touching the ground. During the lateral stability test, the rubber-track behaviour was video recorded to analyse the track-ground interaction.

Non-continuous rolling test

Evidence of non-continuous rolling was carried out by calculation. 17 input parameters were measured for each tractor to be tested and inserted in the mathematical model. Figure 5 refers to a wheeled narrow-track tractor with a front ROPS, as it is considered in the mathematical model with the dimensions and positions of the geometric parameters. Tractor's inertia and CoG height were calculated from the period of oscillation when the tractor was secured on an oscillating platform for two different pivot heights, according to the parallel axis theorem (Casini-Ropa, 1976). The other parameters were directly measured on the tractor (Table 2).

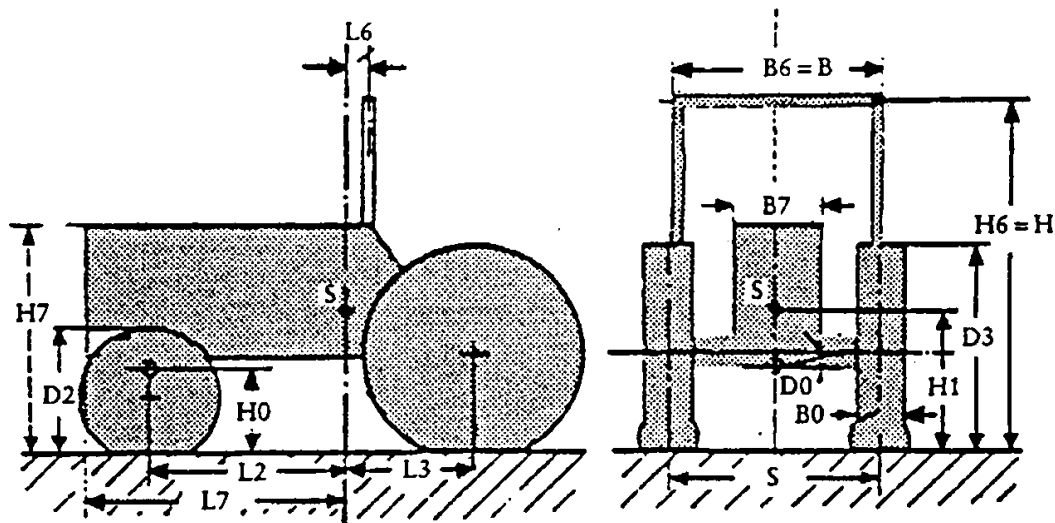


Figure 5. Narrow-track tractor data according to OECD Code 6

Table 2. The 17 characteristic tractor data

B0	Rear tyre width (m)
B6	Width of protective structure between the right and left points of impact (m)
B7	Width of engine bonnet (m)
D0	Front-axle swing angle from zero position to end of travel (rad)
D2	Height of front tyres under full axle load (m)
D3	Height of rear tyres under full axle load (m)
H0	Height of the front-axle pivot point (m)
H6	Height at the point of impact (m)
H7	Height of engine bonnet (m)
S	Rear track width (m)
L2	Horizontal distance between the centre of gravity and front axle (m)
L3	Horizontal distance between the centre of gravity and rear axle (m)
L6	Horizontal distance between the centre of gravity and the leading point of intersection of the protective structure (m)
L7	Horizontal distance between the centre of gravity and the front corner of the engine bonnet (m)
Mc	Tractor mass used for calculation (kg)
Q	Moment of inertia about the longitudinal axis through the centre of gravity (kg m ²)
H1	Height of centre of gravity (m)

Concerning the rubber tracks, among the 17 data of the non-continuous rolling behaviour model, $D3$, height of rear tyres under full axle load, and $B0$, rear tyre width, were defined taking into consideration the track design so as to produce the model output. The height and the width of the rear tyres were replaced by the height and the width of the rubber-track. The mathematical model calculated the unstable angle and the angular velocity during the rollover event. It was then verified if the tractor stopped the rolling by evaluating if the angular velocity decreased to zero when the protective structure touched the ground. The non-continuous rolling behaviour test defines some assumptions in order to simplify the determination of the tractor behaviour during the rollover. In the study the assumption referred to the unstable equilibrium time (Figure 6) was considered. The position of CoG and the mass of the tractor determining the level of potential energy (PE) stored in the tractor system were evaluated for both tractors.

$$PE = M_c g h$$

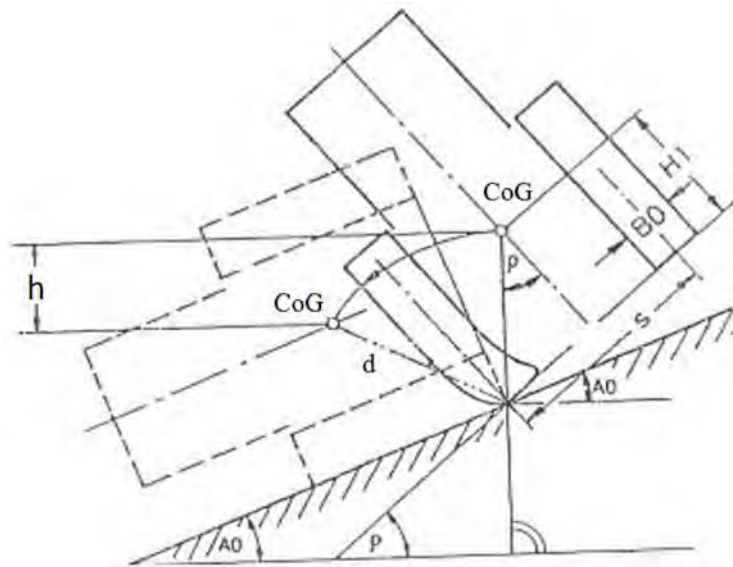


Figure 6. Tyre deflection at the unstable equilibrium time in Code 6 model

Results

Lateral stability test

The lateral stability test had positive results and the tractors were tilted until the state of unstable equilibrium (Figure 7). At the state of unstable equilibrium of the Tractor A, the rotation was around the mid-point of the tyre width because of the tyres deflection. The behaviour of the rubber-track at the state of unstable equilibrium under full load caused the rotation of the tractor around the outer edge of the track. This was mainly due to the non-deflected track under full load and the wider contact surface to the ground. The rubber-track increased the lateral stability angle with respect the tyre because the outer edge of the rubber-track was not subject to deflection. The tractor lost stability when the vertical projection of CoG overcame the rubber-track outer edge (Figure 8).



Figure 7. Tyre and rubber-track behaviour at the unstable equilibrium time

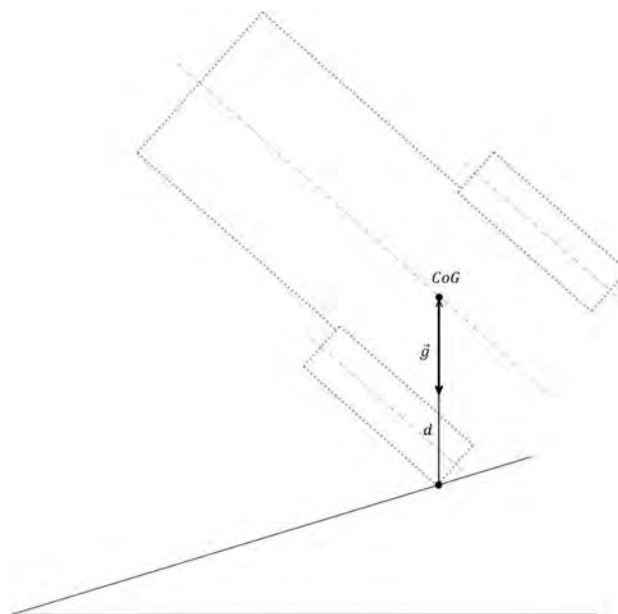


Figure 8. Unstable equilibrium time

Non-continuous rolling test

Non-continuous rolling behaviour was evaluated by calculation on the basis of the 17 characteristic tractor data measured. The measures carried out by the oscillating platform showed the modification of CoG position and moment of inertia about the longitudinal axis through the Centre of Gravity. The CoG of the Tractor B was located downward and rearward with respect to the equivalent Tractor A. The fitment of rubber-tracks replacing the rear tyres increased the tractor mass and the moment of inertia. At the unstable equilibrium time, it was verified the potential energy stored in the tractor system by means of the position of CoG and the mass of the tractor. The potential energy of the Tractor B was higher than that of the Tractor A. The non-continuous rolling behavior results were different for the examined tractors. In case of Tractor A, the calculation gave a positive result and the rolling stopped. On the contrary, Tractor B had a negative result and the rolling continued. The greater mass and the lower and rearward CoG position of the tractor B (fitted with rubber-tracks) increased the tractor angular velocity in the lateral rollover. Consequently, the angular velocity did not

decrease to zero during the lateral rollover calculation (Figure 9) and the non-continuous rolling behaviour was not assessed.

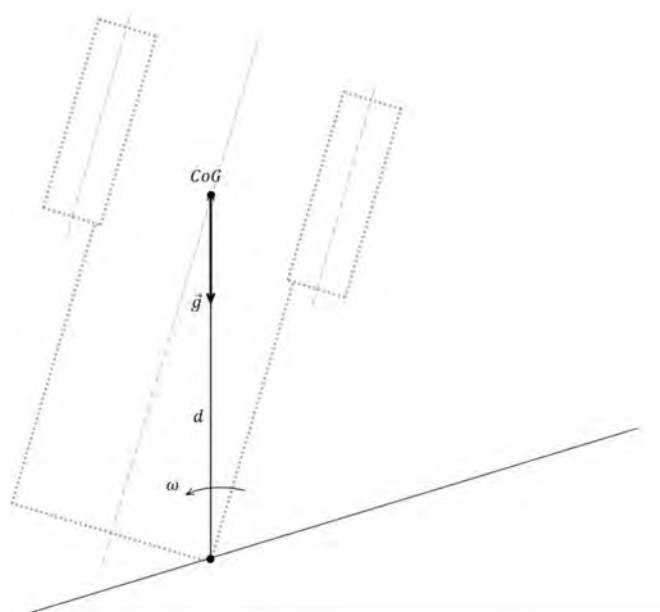


Figure 9. Continuous rolling behaviour

Conclusions

The focus of the study was on the tractor-ground impacts as affected by the introduction of rubber-tracks in replacing the tyres during tractor rollover. The experimental analysis and the observation of the tractor with rubber-tracks during the lateral rollover allowed to understand the differences between the two tractors tested in the phase of lateral rollover. The tractor mass and CoG position measured for the rubber-track tractor affected the stability and the dynamics behaviour in the preliminary test. The analysis of the rollover dynamics seems to confirm that the replacement of the wheels with tracks increases the behaviour to continuously rolling of the tractor. The preliminary test results showed that the non-continuous rolling calculation has to be updated. The rolling behaviour in case of tractor fitted with rubber-track did not correspond to the current assumptions of the Code 6 model for non-continuous rolling behaviour, mainly with respect to the tyre deflection and the tractor pivot point.

The narrow-track tractor fitted with rubber-tracks had a design really close to a wheeled tractor making the comparison between the two tractor types an acceptable approach. This means that potentially Code 6 provisions could cover the ROPS needs of rubber-track tractors. It would be advisable to update the existing mathematical model in order to have for wheeled and rubber-track tractors equivalent levels of safety in the event of tractor rollover.

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Experimental determination of operator perception of tractor instability

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Abstract

Tractor instability is a major cause of serious injuries and fatalities in the agricultural industry. Thus, preventing tractor rollover can have a vital impact in reducing injury risk and saving lives of operators. This study presents preliminary experimental results on the perception of tilt angles. Using a novel tractor driving simulator developed at Penn State, a testing protocol was implemented in order to evaluate the ability of subjects to remember poses at various roll-pitch combinations. Results suggest that roll and pitch are both systematically underestimated, the former more severely than the latter. They also show no statistically significant correlation between the effect of pitch angles on the perception of roll, but do provide an upper bound on typical perceptual errors. These pilot-test results will serve as the basis of a comprehensive study with a wider subject pool. The bigger goal in this effort is to develop rollover alert systems that can prevent these accidents from happening. In that regard, the data obtained from this experiment can be useful in the design and tuning of predictive rollover alerts that promote safe operation of farm tractors, using human perception errors of roll and pitch to guide the thresholds at which warnings should be initiated in each of these directions.

Keywords: Rollover Protective Structure, Tractor Stability, Risk Perception, Stability Research

Introduction

Occupational safety statistics have shown for decades that tractor rollover remains one of the leading causes of fatalities and serious injuries in the agricultural industry. Data from the US Department of Labor's Census of Fatal Occupational Injuries (CFOI) indicate that, out of the 2,320 work deaths that occurred between 2003 and 2007 in the production agriculture sector, nearly 900 of them involved tractors, 43% of which were overturn incidents. While these fatalities have shown a decreasing trend over the last 20 years, the decline is not uniform across all demographic and geographical groups, many of which retain high risk indicators (Myers 2009).

The introduction of Roll Over Protection Structure (ROPS) devices, via legislature or promotion and education programs, has sought to address rollover accidents but various characteristics of the agricultural sector can limit their impact across the industry (Pessina 2010). The fleet of tractors currently in operation is heterogeneous; machines over 20 years old remain popular, and changing technologies in newer models impose challenges on current safety standards (Jarén et al. 2009). Foldable ROPS systems offer favorable solutions for retrofit installation and flexibility, but human factors also interfere with their practical use: “the time, effort, and safety risks associated with operating foldable ROPS limits their effectiveness” (Ayers et al. 2012). In this context, there's a justifiable need to prevent rollover incidents from happening, as a complimentary measure to the use of ROPS (Murphy et al. 2010).

While training and education programs have succeeded, another avenue is to provide in-vehicle technological assistance to operators. As an example, in the automobile industry Electronic Stability Control has been shown to reduce the odds of a single-vehicle crash by 30% in general, and by 49% for sport utility vehicles in particular (Green 2006).

Similarly, intelligent vehicle systems can be brought into the agricultural sector for added safety and accident prevention. Tractor operators determine safe operational limits based on past experience, which is nearly always comprised of situations that did not involve rollover. Thus, warning systems can be used to indicate imminent rollover, but these may be ignored if the driver's perception of the situation does not agree with sensor data.

In this regard, (Nichol et al. 2005) developed a compact, low-cost sensor unit, which employs a microcomputer and a simplified mathematical model to inform the operator of potentially hazardous driving conditions through an LCD display. Furthermore (Tillapaugh et al. 2010) showed that adding a visual slope indicator in the tractor cabin could help operators improve their accuracy in ranking the risk of simulated driving conditions. This experiment was conducted on a tractor simulator with a single degree-of-freedom motion base, setting a precedent for the work presented here.

The goal of this study is to evaluate a tractor operator's nescient perception of vehicle stability, and whether confounding factors such as pitch-roll coupling affect this perception. This paper in particular examines the operator's "memory" of pose, whether this memory is affected by pitch and roll, and how to use this information in the design of rollover alert systems.

The remainder of this paper is organized as follows: first, the Materials and Methods section describes the driving simulator that was used and the test protocol. The Results section summarizes the regression analysis on the data, analysis of regression error, and analysis of absolute error. The primary findings of this work are then summarized in a Conclusions section.

Materials and Methods

Tractor Driving Simulator

This study utilizes a novel tractor simulator shown in Figure 1 wherein a tractor cab is mounted on top of a custom-modified motion base that enables +/- 28 degrees of roll motion and +/- 18 degrees of pitch motion. The motion base is comprised of two parts. First, a commercial off-the-shelf industrial parallel robot manufactured by Moog, with 6 degrees-of-freedom for full 3D motion, which provides up to +/- 18° of pitch and roll for a 2,000 lb. payload. Additionally, an inverted slider-crank (IS-C) mechanism (detailed on the right in Figure 1) was designed and installed between the Moog robot and the tractor cabin, providing an additional 10° of roll in each direction, relative to the Moog's motion base position.

The simulator also includes an 8 ft. tall, 360° surround screen with 12 High-Definition projectors for an immersive simulation environment. The whole system (Moog robot, IS-C mechanism, projectors and cabin sensors) is operated through a cluster of 9 Linux-based computers, networked with the Robot Operating System (ROS) and running the Gazebo simulation software, which are both open source.

Prior to conducting any tests, the motion system was calibrated to verify the precision of its tilting motion. Total roll angles were measured using a digital slope-meter, with resolution of 0.01% slope (equivalent to 0.06°) (Figure 1, right image). This was used to calibrate both the commands that are sent to the Moog robot, as well as the custom-built roll-tilt mechanism.

The mechanism employs a linear actuator instrumented with a string potentiometer to control the cabin's roll angle relative to the Moog, as well as an encoder with 40,000 counts-per-revolution installed on the shaft around which the cab rotates. Both give precise relative control of the cab's motion, and additionally allow control if there is an intermittent power failure in the system. During subject testing, the positioning errors of the custom motion base were recorded and found to be negligible: $0.07^\circ \pm 0.28^\circ$ (95% confidence).

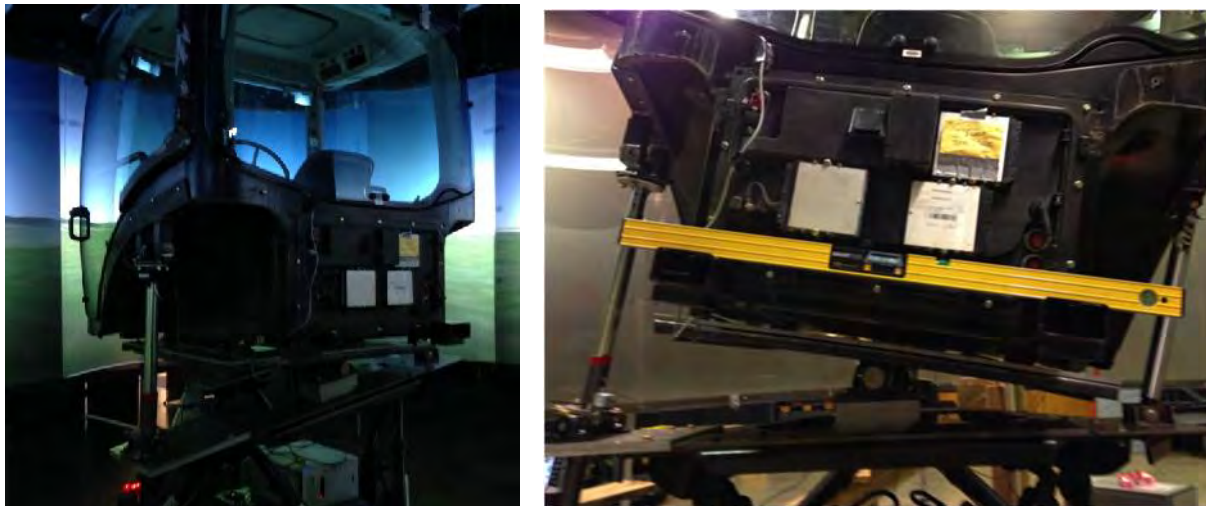


Figure 1. On the left, the tractor driving simulator; on the right, the IS-C mechanism fully extended for 10° of additional roll relative to the Moog robot.

Test Protocol

Once the system was calibrated, operators were tested on their ability to remember various roll-pitch combinations. The test protocol consisted of the following steps:

1. The test subject boards the simulator and the system is initialized.
2. The motion base moves the cabin to a set roll-pitch combination, and remains stationary for 5 seconds, after which it returns to level.
3. The subject is then instructed to operate the motion base (using a videogame controller) until they reach what they believe is the same angle at which the motion base paused earlier.
4. Once the subject is satisfied with their position, a data point is recorded, registering the original roll-pitch angles and the subject's perceived roll-pitch.
5. The platform is returned to level, and steps 2-4 are repeated for the 28 tilt angles across a randomized pattern.

The set of tilt angles is shown in Figure 2. The reader may note that the set is not symmetric; two angles on the top left corner are missing. They were removed from the sequence because the Moog motion base can be overloaded in force when tilting the cabin to these large angles. This happens because the mass of the cabin in this severe roll-pitch combination is close to the maximum payload, and additional motion past this point has the potential of overloading the motion base's actuators.

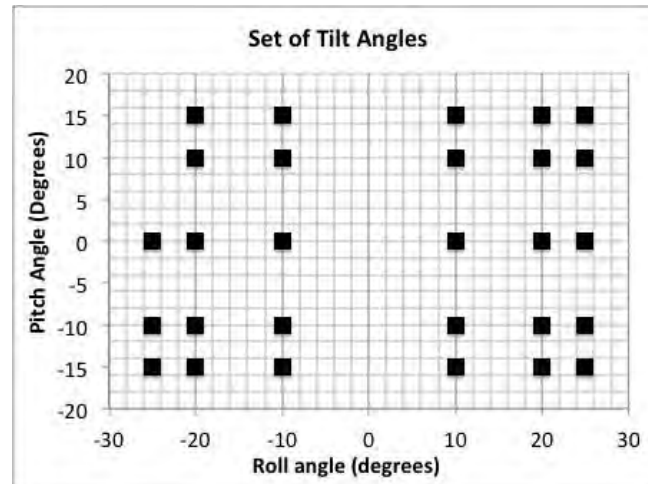


Figure 2. Subjects were exposed to 28 tilt angles of various roll-pitch combinations.

The sequence was presented in randomized order, so that every subject goes through the same angles, but in a different order. This was done to prevent skewing the results with fatigue during the test, as measurement of all angles for a test subject takes around 50 minutes to complete.

During the test, a fixed image with a virtual rural scene is projected on the screen. The subjects are instructed to look at the screen during the whole procedure. The intention here is twofold: first, observance of the horizon line is considered an important visual cue for tilt estimation in the open field; second, in order have the subjects refrain from using external visual cues –ones which would be unavailable in the natural driving environment, such as the top/bottom edges of the screen, or the screen structure– to aid in their tilt estimation task.

Preliminary testing was done with pilot test subjects in order to evaluate the system’s performance and polish the software that controls the experimental protocol. During this process, full and consistent data was collected for four subjects, and its results and analysis are presented in the following section. Testing is ongoing at present using an identical protocol but with a deeper subject pool including up to 60 tractor operators, of varying degrees of experience, age and other demographic factors. These results will appear in a follow-up publication.

Results

The graphs in Figure 3 plot the pilot-testing subject pool’s perceived tilt angles versus the angles they were exposed to. The figure on the left does so for roll, and the one on the right for pitch. The graphs show three types of information: first, the individual data points for all subjects (28 per subject); second, a linear regression of these points (in thick blue line) with its corresponding equation; and third, the ideal result for the regression if the subjects were to have perfect tilt angle estimation i.e., slope equal to one, and intercept equal to zero.

The first notable result is that the roll angle is systematically underestimated, having a slope of 0.88 with 95% confidence interval (0.85, 0.92), compared to the ideal value of 1.00. Meanwhile, the intercept is 0.23° –with 95% confidence interval (–0.85°, 0.40°), meaning that the estimation can be assumed to be unbiased:

$$roll_{perceived} = 0.88 \cdot roll_{actual} + 0.23^{\circ}. \quad (1)$$

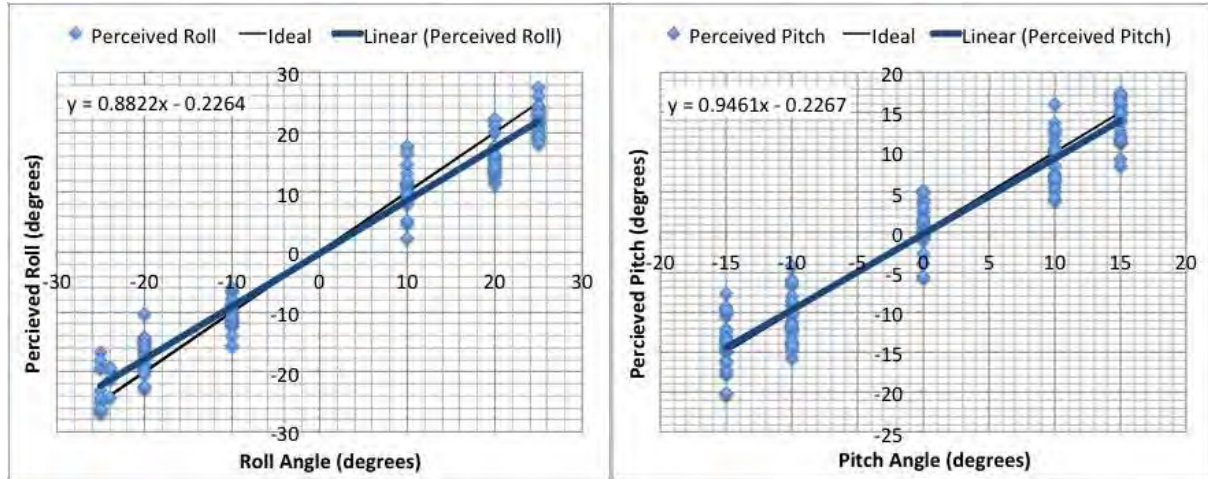


Figure 3. Tilt perception plots show that roll and pitch are systematically underestimated and unbiased. Roll on the left; pitch on the right.

Similarly, pitch is also underestimated, with slope of 0.95 with 95% confidence interval of (0.89, 1.00), and can be considered to be unbiased, with intercept of -0.23° with 95% confidence interval $(-0.81^\circ, 0.35^\circ)$:

$$pitch_{perceived} = 0.95 \cdot pitch_{actual} + 0.23^\circ. \quad (2)$$

Interestingly, roll perception has a bigger issue with underestimation than pitch, meaning that roll perception errors have a dominant effect over pitch perception errors, and thus would pose a larger threat during risky driving tasks at high tilt angles.

While these two regression models had good fit (R^2 values of 0.962 for roll and 0.923 for pitch), other regressions that were attempted showed poor goodness of fit values, which can be indicative of the independence of certain variables in the experiment. For example: from current results, pitch angle does not appear to have an appreciable influence on roll estimation. For the model

$$roll_{perceived} = m_p \cdot pitch_{actual} + b_p, \quad (3)$$

the regression results in a slope of 0.1503 $(-0.1314, 0.432)$ which can be considered statistically insignificant, as it contains zero well within its 95% confidence interval, as well as a negligible goodness of fit metric: $R^2 = 0.010$. For further confirmation, a two-factor model on roll estimation,

$$roll_{perceived} = m_1 \cdot roll_{actual} + m_2 \cdot pitch_{actual} + b_t, \quad (4)$$

produced a good fit ($R^2 = 0.962$), with slope $m_1 = 0.88$ $(0.85, 0.92)$ which is statistically significant and consistent with the regression model from Figure 3, while a slope $m_2 = 0.004$ $(-0.05, 0.06)$ which, like the earlier pitch-only regression model, is not statistically significant. Similar results were obtained for the influence of roll angle on pitch estimation. The current data set does not show a significant effect of pitch affecting the subject's roll perception, or vice versa.

Average Errors

Another issue that was examined was the possible influence of tilt angle magnitudes on the subjects’ estimation errors. Figure 4 shows the mean estimation error, with corresponding 2- σ error bars (for 95% confidence), at different roll and pitch magnitudes.

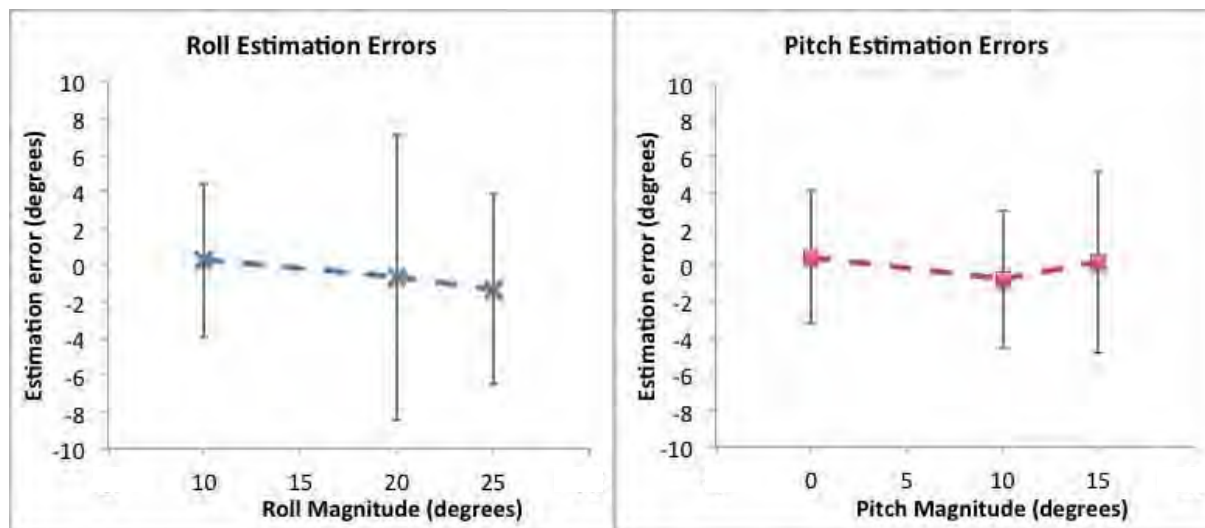


Figure 4. Estimation errors are not strongly influenced by angle magnitude. Roll is shown on the left; pitch on the right.

The mean of the roll estimation errors show a slight tendency to slope downwards as roll magnitude increases. However, the averages for all three cases are below 1.4° in magnitude, while the confidence intervals range between +/- 4.2° and +/- 7.8°. In that regard, any apparent pattern cannot be considered statistically significant. A larger sample would be required to draw a conclusion on this relationship, and tests on larger subject pools are ongoing. In similar fashion, the mean pitch errors have slightly smaller variability compared to roll (ranging between +/- 5.1° and +/- 6.9°) but again show small magnitudes (below 1.4°) and no statistically significant impact from pitch magnitude.

What these plots do show, however, is that errors for both roll and pitch are centered close to zero, meaning there’s no clear bias towards positive or negative estimation errors. The two-variable relationships (roll error vs. pitch magnitude, and pitch error vs. roll magnitude) were also not statistically significant, and are thus omitted for brevity.

Absolute Errors

One final indicator that was analyzed was the absolute value of the estimation errors, or the distance-to-truth. This is a measure of how far off the subject’s perception is from the true tilt angle, irrespective of whether they incurred in over-estimation or under-estimation. Figure 5 shows the average distance-to-truth for different angle magnitudes.

As was the case for the error averages, the distance-to-mean metric does not show a clear pattern or influence from tilt angle magnitude. However, it does reveal three key trends:

- Pitch estimation has lower mean absolute errors than roll (below 2.7° vs. up to 4.0° in roll), and can thus be said to have higher estimation accuracy. Test subjects can apparently perceive pitch with more accuracy than roll.
- The variability of distance-to-truth for pitch does increase with pitch magnitude, as seen from the error bars. At zero pitch the 95% confidence interval is very small

+/- 0.6°, and it increases at 10° to +/- 1.6°, and further increases at 15° to +/- 2.13 °. Thus, test subjects appear to become worse at perceiving pitch with larger pitch angles.

- For the pitch and roll angles of interest in this study – namely those that are near the rollover or skidding threshold of an agricultural tractor, absolute roll errors of up to 4°-5° would be expected to be commonplace; for pitch, absolute errors up to 3°-4° would be widely expected.

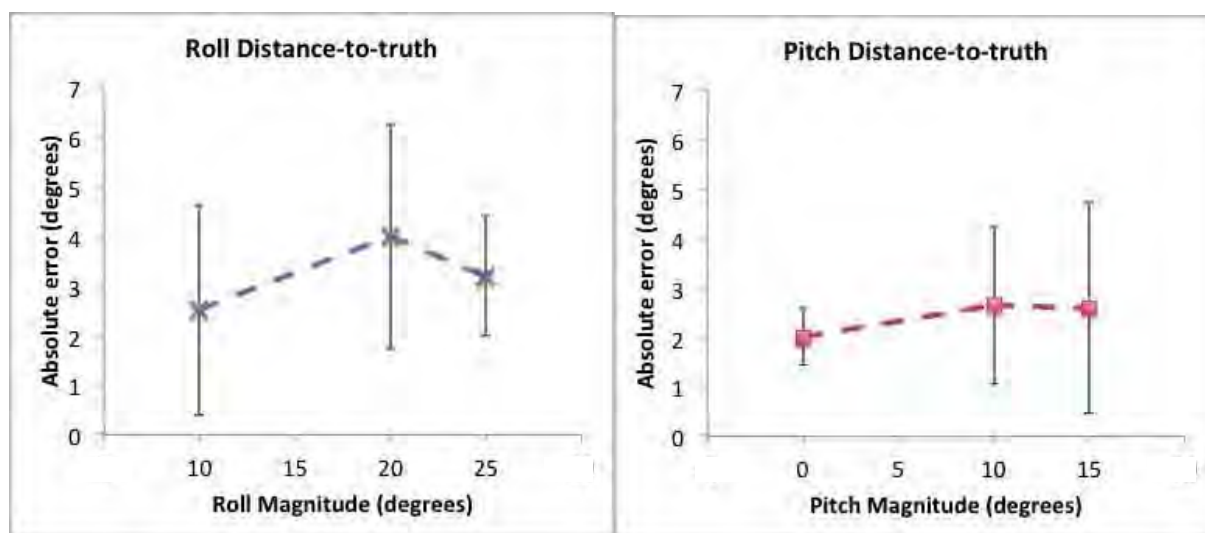


Figure 5. Distance-to-truth averages show the magnitude of typical perception errors.

This last observation can be a useful indicator in tuning a rollover alert system, knowing that a tractor operator driving on a 20° roll slope can commonly perceive this to be in the 15°-16° roll range, therefore underestimating the risk of a rollover accident. Any warning system for roll should therefore give a severe warning within 4 degrees of a tractor’s actual rollover threshold.

Conclusions

This study on a pilot-test pool provides insights that are useful for tractor warning systems. In particular, subjects systematically underestimated roll, but produced unbiased errors. Pitch was also systematically underestimated, but to a lesser degree, and was also unbiased.

The current data set showed no two-variable relationships between roll estimation and pitch angle, nor one for pitch estimation and roll angle. While the expectation was that combined roll-pitch angles would prove to be more difficult to estimate correctly, the results suggest that roll and pitch estimation operate independently in terms of human perception.

Estimation errors for both roll and pitch are centered close to zero, further evidence of the absence of bias, and do not exhibit a relevant relationship with tilt angle magnitudes.

In similar fashion the mean absolute errors, or distance-to-truth, showed no influence from tilt angle magnitude, but do provide upper bounds on typical roll and pitch estimation errors. Such bounds can be useful in determining the threshold for a rollover alert system, as they offer a statistically-supported worst-case scenario for roll underestimation, which can lead to dangerous tractor operation on steep hills.

These conclusions based on this preliminary data set have provided guidance on testing with a wider subject pool (close to 60 subjects), which will include experienced and novice tractor operators of different ages. Additionally, these results are useful to develop prototype tractor rollover and pitch-based warning systems to be tested with that same test pool.

Acknowledgements

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Narrow-track agricultural tractors: a survey on the load of hand-operated foldable roll-bar

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Abstract

To protect the operator in case of overturning, the narrow-track tractors (used in vineyards and orchards) can be equipped with a ROPS consisting of a 2-pillars front mounted foldable roll-bar.

The handling of this type of ROPS, in particular the transition from the horizontal (rest) to the vertical (protection) positions, is generally operated through two removable pins managed manually by the driver of the tractor. Apart the time necessary to perform some times a day this operations sequence, a moderate/medium physical load should be also required, given that often these roll-bars have a mass of some tens of kilograms.

The reality is indeed quite different, since neglect and a poor attention to safety lead to the condition in which the foldable roll-bar remains continuously in the rest condition and is no longer moved back in the vertical (protection) position. Several roll-over accidents were fatal for the operator because the tractor, although equipped with a 2-pillars front mounted ROPS, at the time of the event had the roll-bar in the horizontal (rest) position, so assuring no protection to the driver.

This issue is quite serious. To remove at least one of the problems for the proper managing of this type of ROPS, the OECD have recently updated its Code 6, by introducing an optional test dealing with the manual handling of the front mounted roll-bar, providing a maximum load of 100 N.

Several tests on new roll-bars were carried out to ascertain the respect of this limit. The 100 N value is generally exceeded, so showing its criticism. Indeed, a more appropriate reference for the manual handling should be in this case higher load values (up to 250 N) already provided by several Standards for non-continuous tasks.

Keywords: Tractor Overturning, Front Mounted ROPS, Raising Force

Introduction

Since the '50s of the last century, the most frequent type of accident occurring with agricultural tractors is the overturning. The relevant injuries can be prevented with some success by fitting Roll Over Protective Structures (ROPS), combined with the fastening of a driver's seat belt. In many countries, authorities have imposed this type of protection on tractors for many years (*Springfeldt, 1996*). The Scandinavian countries were the first group of countries to issue mandatory regulations and obtain encouraging results: in Sweden, the frequency of fatal rollovers per 100 000 tractors per year decreased from 17 to 0.3. In Norway, the frequency of fatal rollovers decreased from 24 to 4 from 1961–1969 to 1979–1986 periods. In Finland, the frequency of fatal rollovers decreased from 16 to 9 from 1980 to 1987. Moreover, from 1961 to 1986 the frequency of fatal rollovers in West Germany decreased from 6.7 to 1.3.

A widely recognized criterion considers the amplitude to classify the tractor roll-over, in particular if the tractor at the end of its overturn has rolled no more than 90° or was

subjected to continuous rolling. In any case, many of the accidents occurring during agricultural activities are not officially recorded for many reasons. A comparative study of 388 fatal accidents related to agricultural machinery occurred in Spain from 2005-2010 concluded that only 61.9% of the deaths were regularly reported. In any case, based on 272 reported fatal overturning accidents, the main cause of death was the lack of a ROPS on the tractor; only one accident involved a tractor that was equipped with a homologated ROPS (Arana *et al.*, 2010).

In Italy, the fitting of a ROPS on new conventional tractors has been compulsory since 1974. In the following decades, this requirement has been gradually extended to other tractor categories. In particular, the so called “narrow-track” tractors (frequently used in vineyards and orchards) must be equipped with a ROPS since mid ‘80s of the last century. The strength of the ROPS is verified using a series of loading tests, which are specified in dedicated standards issued by international organisations (EU, OECD, ISO and SAE) (*OECD Standard Codes*, 2014).

Starting from an official figure of 200 fatalities in the early 1970s, INAIL currently reports that an average of 25-30 deaths per year are caused by the overturning of agricultural tractors. Surveys from different sources reveal a considerably higher number of fatalities (Pessina and Facchinetti, 2011).

This large discrepancy is attributed to the notion that the compensation for injuries (fatal or nonfatal) is typically related to the so called “professionals”. However, in agriculture, the operation of tractors on a secondary basis by an extensive variety of non-professional workers is common.

The official mode of the recording, classification and management of these events produces dynamics that do not facilitate prompt and updated monitoring on a national scale. The consensus is that a real situation is different and the consideration of alternate solutions may enable a real overview of these situations.

The Web has recently changed with regards to the approaches used to communicate information. Many international, national, and local portals were established to systematically report news that has relevant significance (*blogspot “Caduti sul lavoro”*). Thus, a fatal accident at work, such as a tractor overturning with one (or more) victim(s) will not go unnoticed even if is not mentioned by the press at a national level, as it will be reported on local web portals (of regions, municipalities, local TV, newspapers and news sites) and on numerous blogs.

Since 2008 fatalities due to agricultural tractor overturning were systematically recorded by examining many web portals of news and information. The maximum detail level was extracted from each portal and subsequently used to construct a truthful, effective and timely scenario of the situation. Indeed, the adopted method has some limitations: the obtained values do not completely reflect the real situation and the details of the reported events are not completely congruent and may be subjected to the inaccuracies of the press. Notwithstanding these problems, the survey highlighted that in approximately 55% of these cases the tractors were not equipped with ROPS (fig. 1). In 30% of the cases, the type of ROPS fitted was the 2-post front-mounted foldable roll-bar. Considering only the overturning accidents that involved tractors equipped with a 2-post front mounted foldable roll-bar, the roll-bar was determined to be in a horizontal position, which assures no protection, prior to the fatal event in 80% of the cases.

This finding represents a quite critical condition that requires urgent countermeasures.

On narrow track tractors, the roll-bar is foldable to allow travelling inside of the vineyards and orchards rows without damaging the branches for the possible entrapment with the pillars and/or entering of the tractor into low height garage doorways.

In all the other working tasks, the roll-bar must be maintained in a vertical (protection) position.

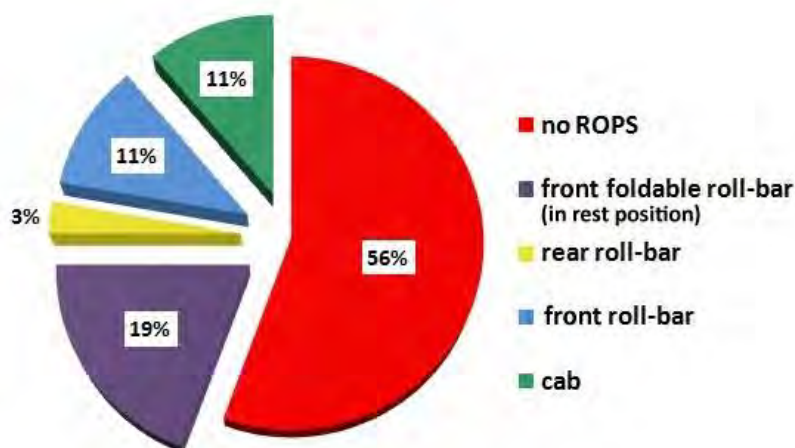


Figure 1. Type of ROPS fitted on agricultural tractors involved in fatal overturning accidents occurred in Italy in the period 2008-2014.

The transition between the horizontal (rest) to the vertical (protection) positions (and viceversa), is generally operated through two removable pins managed manually by the driver of the tractor. Apart the time necessary to perform some times a day this operations sequence, a moderate/medium physical load should be also required, given that often these roll-bars have a mass of some tens of kilograms.

Thus, several of the reported roll-over accidents involving tractors equipped with a 2-post front-mounted foldable rollbar were fatal for the operator because the tractor at the time of the event had the roll-bar in the horizontal (rest) position, so assuring no protection to the driver. The main complaint facing this problem is the excessive manual load to be exerted to manage the roll-bar.

The present survey is devoted to ascertain the real handling loads of the front foldable roll-bars, to be compared to the values provided by the relevant general standards and a new measure recently introduced in the OECD Code 6, dealing with the strength test of the front foldable ROPS to be fitted on the narrow-track tractors.

Materials and method

The roll-bar handling loads were ascertained on new narrow-track tractors, at different inclination angle values, when raising the ROPS. The recently introduced new optional test into the OECD Code 6 provides the clear and indelible identification of a so called “grasping area”, defined by the manufacturer on the roll-bar pillar(s) and designed to handle manually the roll-bar by a standing operator (fig. 2).

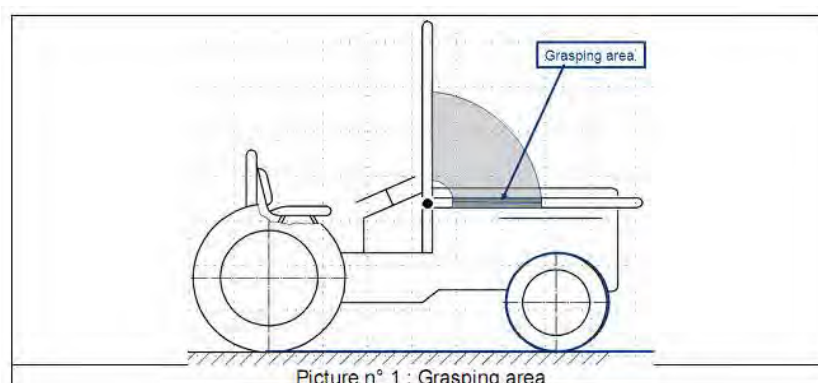


Figure 2. Detail of the so called “grasping area”, a zone designed to handle manually a 2-pillars foldable front mounted roll-bar by a standing operator.

Three accessible zones with different amounts of allowed force are defined with respect to horizontal plane of the ground and the vertical planes tangent to the outer parts of the tractor that limit the position or the displacement of the operator, as follows (fig. 3).

- zone I : comfort zone;
- zone II : accessible zone without forward leaning of the body;
- zone III : accessible zone with forward leaning of the body;

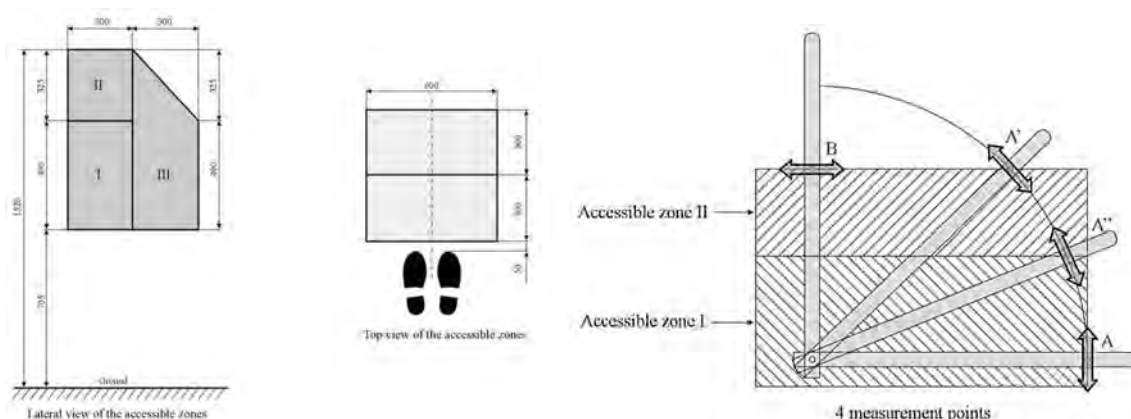


Figure 3. Dimensions of the 3 accessible zones for the handling of the foldable front roll-bar (left) and sketch of the procedure to be followed for measuring the forces for the foldable front roll-bar handling (right).

Each force measurement necessary to raise or lower the roll-bar shall be made in a direction tangent to the trajectory of the roll-bar and passing through the geometric centre of cross sections of the grasping area, in a static condition. It is provided that the force shall be measured in different points that are within the accessible part of the grasping area.

The first measure is carried out at the extremity of the accessible part of the grasping area when the roll-bar is fully lowered (point A). The second is defined according to the position of point A after rotation of the roll-bar up to the top of the accessible part of the grasping area (point A'). If in the second measure the roll-bar is not fully raised, an additional point shall be measured at the extremity of the accessible part of the grasping area when the roll-bar is fully raised (point B). Moreover, if between the first two measures the trajectory of the first point crosses the limit between zone I and zone II a measurement shall be made at

this crossing point (point A”). In order to measure the force in the required points, it is possible either to measure directly the value or to measure the torque needed to raise or lower the roll-bar so as to calculate the force. The force acceptable for the actuation of the ROPS depends on the accessible zone, as shown in tab. 1.

Table 1. Maximum actuation force values provided by OECD Code 6, depending on the accessible different zones.

Zone	I	II	III
Acceptable force (N)	100	75	50

Starting from the described procedure, some tests preliminarily carried out ascertained that, as expected, very often the operators start to raise the roll-bar lying in the horizontal position grasping it at its absolute top, and not at the top of the defined grasping area (i.e. at 1520 mm from the ground). For this reason, the static raising force values were measured at the top of the foldable part of the roll-bar, when lying in the rest (approx. horizontal) position and for 8 of the 17 tractors investigated, in other 5 significant conditions (always in a perpendicular direction to the tangent of the trajectory), i.e. at angles of 0°, 30°, 45°, 60° and 90° in respect to the horizontal plane, always at a distance of 1520 mm from the ground when the roll-bar is in the vertical (protection) position (fig. 4).

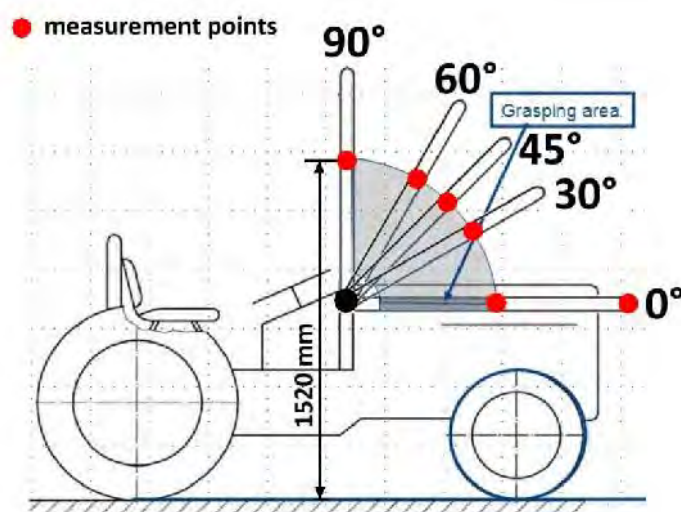


Figure 4. Measurement point locations and angles of inclination of the roll-bar at which the raising force was measured.

17 new narrow-track agricultural tractors were examined; they all were equipped with a 2 front-post foldable roll-bar, having a mass of the foldable part varying from 8 to 34 kg. Inside of the machines group investigated, traditional wheeled (10), articulated wheeled (6) and tracked (1) models were included.

To measure the force values, an integrated load cell with a digital display was used, make Macmesin model AFG 500 N, having a full scale of 500 N (plus an overload capacity of 50%) and a reading sensitivity of 0.01 N, while the inclination was measured thanks to a digital inclinometer make Lucas model Anglestar, with a minimum reading sensitivity of 0.1° (fig. 5).

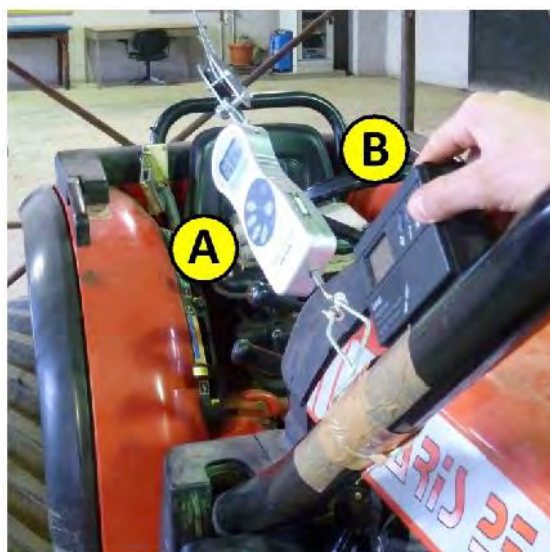


Figure 5. Execution of a static raising force measurement. A - integrated load cell with digital display; B - digital inclinometer.

Moreover, apart the recently introduced new optional test into the OECD Code 6, also the ISO 11228-1:2003 standard “Ergonomics – Manual handling – Part 1: Lifting and carrying” (ISO, 2003) was considered. This Standard takes into account the intensity, the frequency and the duration of the manual lifting and carrying of the loads.

For the lifting condition (appearing the most similar to be applied for the roll-bar raising) in the Annex C of the ISO 11228-1 is considered a limit of 25 kgf (approx 250 N) for a non repetitive task (frequency less than 1 time/minute), for adult working population and professional use. If these parameters seems to be correctly applicable to the action considered in this case, it is stated that the amount of population protected is 85% as an average (95% of the males and 70% of the females). Moreover, taking into account that the operators working in agriculture (and above all those driving and managing agricultural machinery) are for the 99% males, it should be concluded that the figure of 250 N may be appropriated to be considered a suitable limit. For this reason, both the limits (100 N, OECD Code 6; 250 N, ISO 11228-1) were compared to the obtained results.

Results and discussion

For all the 17 tractors examined, in fig. 6 the raising force values recorded at the top and at a height of 1520 mm from the ground are shown, when the roll-bar was in the rest (horizontal) position, i.e. at a conventional 0° angle. Indeed, in some cases the rest position was varying up to 8-10° above or below the horizontal line, due to different design solutions, devoted to minimize the view obstruction of the roll-bar to the driver, of course taking into account the bonnet contour. This parameter could have affected the initial raising force value, but in any case a good simulation level was assured in measuring the real operator's load.

All the force values obtained exceeded the 100 N limit, apart those of the roll-bar fitted on tractor no. 16 and that of tractor no. 1, being in this last case equipped with a couple of gas springs. In other words, *in 88% of the examined cases the limit was overcome*. On the contrary, considering the data obtained at the top of the roll-bar, the limit was exceeded only

in 11 of the 17 cases (65%), but in many other tests the recorded value was a little bit higher than 100 N. Comparing the data to the limit of 250 N provided by the ISO 11228-1 standard, the force was exceeded only in 8 of the 17 tests (47%) at a height of 1520 mm from the ground, while all the values at the top of the roll-bars were lower.

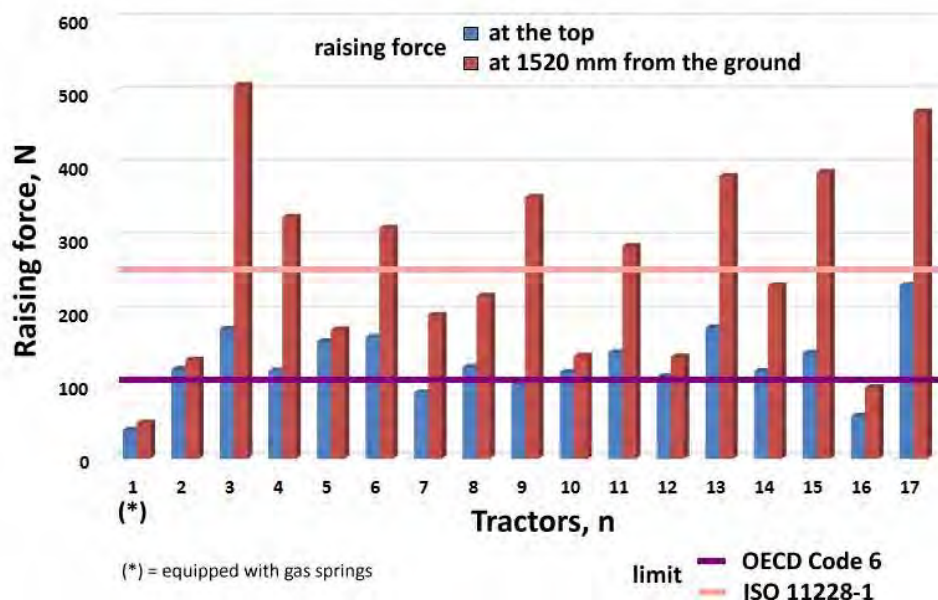


Figure 6. Raising force values of the investigated roll-bars at conventional 0° angle, at the top of the ROPS and at a height of 1520 mm from the ground, as provided in OECD Code 6 optional test.

This is a first evidence on how the limit taken into account may affect remarkably the need to improve the roll-bar handling (i.e. by fitting an aiding device).

Considering the typical handling of the roll-bar taken into account, i.e. its rotation for an overall angle of approx. 90° referred to a hinging point, a strong link from the roll-bar mass and the raising force should be found. Unexpectedly, the relevant results show a poor correlation between the two parameters (fig. 7).

Indeed, the raising force is affected not only by the roll-bar mass (and of course by the height of the foldable part), but also by the friction of the pins on which the foldable part of the roll-bar is rotating.

Sometime, the friction force reaches a remarkable figure, due to the limited tolerance between the diameters of the pins and that of the holes in which they are fitted. In fig. 8 the raising force trends for inclination angles from conventional 0° to 90° for 8 of the 17 tractors examined are shown.

Notwithstanding the force values quite different, as expected the maximum raising force was recorded at the horizontal position, apart one case, where at 30° a remarkable value was recorded, due probably to a high pin friction. Moreover, in many cases till to 30° of the roll-bar inclination (starting from the horizontal) the force tends to remain high, decreasing more or less suddenly for angle values over than 30°.

The opposite trend was recorded when gas springs are fitted, probably due to the typical behavior of these aiding devices. In any case, the gas springs allow to decrease remarkably the raising forces over all the roll-bar excursion.

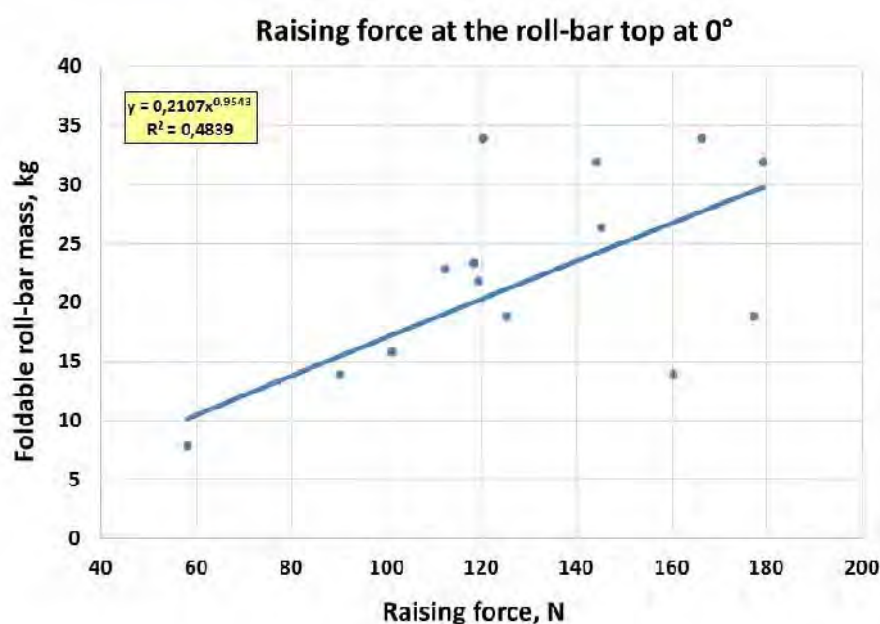


Figure 7. Comparison between the roll-bar mass values and the correspondent raising forces recorded at the top of the roll-bar.

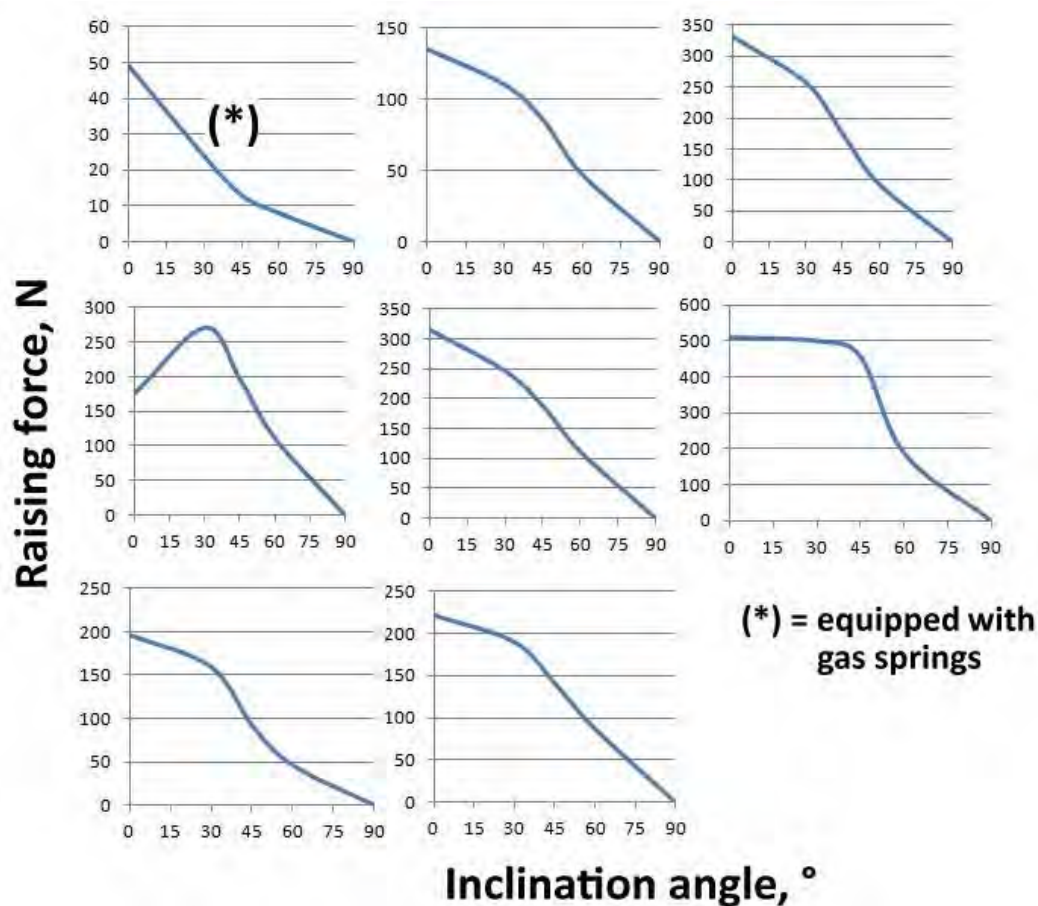


Figure 8. Raising force trends for inclination angles from conventional 0° to 90°, for 8 of the 17 tractors examined.

Conclusions

In Authors' opinion, the force limit of 250 N seems to be more appropriate in respect to 100 N value; in fact, it is a figure established in an ISO International Standard, diffused at a worldwide level, for non-continuous tasks of workers (like the roll-bar handling is) and statistically validated for a quite high percentile (95%) of male operators, thus representing well the manpower employed in agriculture. Although the data obtained in this survey are not completely exhaustive, the relevant trend is sufficiently clear, i.e. the 100 N limit is exceeded on practically all the roll-bars. As a consequence it should be respected only by fitting an aiding device (gas springs or hydraulic cylinder(s)). Viceversa, the 250 N limit appears fully justified under the ergonomic point of view and allows the handling of several roll-bars without any supplementary mechanism. On the other hand, some roll-bars show a very remarkable weight and are exceeding also the higher limit, so that an aiding device should be necessarily provided. Again, in the Authors' opinion, this could be a quite well-balanced approach to the problem, finalized to reduce effectively the handling load to be developed by the narrow-track tractor driver, but at the same time able to avoid difficulties in adapting many roll-bars to an unjustified low force limit. The next step (already made by some manufacturers) is to avoid at all the manual handling of the roll-bar, by introducing different levels of automation. Firstly, one (or two) raising hydraulic cylinder(s) could be fitted and operated manually, by means of a leverage or a button; a further level could be represented by the fully automation of the roll-bar position depending on the dangerous conditions occurring (i.e. lack of lateral and/or longitudinal stability). In any case, the safety belt should be fitted and above all should be correctly fastened; in fact, if the operator is not safely fixed to the seat, it is quite probable that, especially in case of lateral overturning, he/she is thrown out and is fatally hit by the ROPS, the device that on the contrary should have assured a proper protection.

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Design Considerations in fixture development to Retrofit ROPS on Agricultural Tractors

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Abstract

Tractor population has reached about 5 million in India. Though being the largest tractor market, rollover kind of accidents have not got attention so far. Recent tractors are being equipped with safety devices such as SMVE, NSS and safety guards on moving parts. Stability sensors are also being thought-off to inform overturning situation. In fact, ROPS retrofitting is one of the best engineering controls for passive safety of rollover accidents through ROPS is not compulsory accessories of tractors. Therefore, operators' safety is at stack. Regulations coupled with design variation of various tractor models are hindering the use of market/common ROPS for retrofitting on tractors. Therefore, investigation has been planned to develop a fixture to retrofit ROPS to insure operators' safety.

To develop mounting fixture, medium range horse power tractors has been targeted. Two way approaches have been adapted to design fixture. First, in view of design of structural mount point and second, ROPS cross sectional view point. Structural mounting location is nothing but axle housing of various tractor models. These all have been clustered based on geometrical similarity of axle housing followed by strength predication of selected pre-ROPS axle housing. Alike to axle housings design parameter of ROPS were also considered.

It was found that most of the axle housing were circular in shape so as structural mount point. The critical diameter and thickness were varying about 90-250 mm and 14-18 mm respectively. Developed fixture could accommodate maximum of 70 mm × 90 mm prismatic cross section and up to 90 mm diameter of circular. Fixture was found capable of satisfying requirements of IS: 11821(Part 2) identical to OECD test code. Proper implementation of fixture along with regulation expected to reduce fatalities of tractor operator.

Keywords: ROPS Retrofitting, Axle housing, Design.

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