Materials and Methods: The literature was searched to identify tools that estimate risk of shoulder injury or fatigue and reviewed on input and output factors and usability for design.
Results: The tools identified were RULA, OCRA, The Shoulder Tool, and a new design tool to estimate maximum acceptable arm forces based on hand location. The first 2 tools provide generic cautionary outputs for above shoulder work, e.g, “change may be needed”. The 2 later tools provided more detailed design-oriented output with hand force limitations based on 3D hand posture above the shoulder. The Shoulder Tool estimates risk using a fatigue failure model using the shoulder load moment for a single hand location for a 50th% male and incorporates the effect of repetition. The tool provides cumulative exposure estimates for multiple tasks, and has been validated against physician-diagnosed shoulder tendinitis and other shoulder outcomes. The design tool is based on 25th % female strength at 3D hand locations above the shoulder and considers supraspinatus tendon impingement and shoulder muscle fatigue.
Conclusions: The risk assessment tools reviewed were designed for different purposes and each has their own limitations. Risk assessment tools that provide specific hand force limits relative to repetition rate and hand location may be the most useful for workstation and task design.

Special Session 15 Occupational safety and health strategies for engineered nanomaterials: a model for emerging technologies

Chair: Ivo Iavicoli

Session introduction

It will be tracked the history of Occupational Safety and Health activities and nanomaterials, the actions with the current evolution (additive manufacturing advanced materials and manufacturing), then it will be described how the approach could be generalized. The idea is to have a session that looks at how the occupational safety and health community addressed nanotechnology and discuss how that might be a prototype for dealing with other emerging technologies.

Sp16-1

Improving human control of hazards in industry

Maureen Hassall

School of Chemical Engineering, The University of Queensland, Brisbane, Australia

Introduction: Hazards are the things that can cause harm to people, the environment and organisations. The production of nanomaterials entails hazards but nanomaterials can also be a hazard. The management of industrial hazards, such as those associated with nanomaterials, is an important and challenging human endeavour.
Materials and Methods: The control of hazards is usually done by identifying, assessing and treating risks as per ISO31000. Contemporary processes for determining the assessment and treatment of hazards followed a semi-structured brainstorming analysis approach that is recorded in simple/unintelligent software.
Results: Inadequate hazard analysis has been found to be a direct or contributing factor in over half major oil and gas incidents. In addition, the failure to implement and/or maintain well known controls for well known hazards that also been a significant factor in most major accidents. Thus more could be done to improve human control of hazards in industry.
Conclusions: To improve the control of hazards, the ISO31000 framework should be extended to put equal emphasis on risk treatment as it does on risk analysis and management. In addition, hazard identification, assessment and control requires human decisions and actions. Thus, improving human control of hazards requires the adoption of human-centred design approaches in hazard management systems. In doing so, the opportunity exists to enhance human’s control of hazards with the smart use of Industry 4.0 technologies. However, these technologies can also introduce new, and emergent hazards so applications need to be well thought through and managed.

Sp15-2

OSH strategies to Industry 4.0: the example of risk assessment and management of nanomaterials

Ivo Iavicoli, Luca Fontana and Veruscka Leso

Department of Public Health, University of Naples Federico II, Naples, Italy

Introduction: Industry 4.0 refers to new developments in automation and data exchange in manufacturing technologies. Its pillars include internet of things, big data, augmented reality, cybersecurity, collaborative robots, additive manufacturing, cloud computing, artificial intelligence, and nanotechnology. Although providing great solutions, industry 4.0 can also lead to new occupational health and safety risks, requiring suitable risk assessment and management. We aimed to extrapolate, from the nanotechnology areas, issues useful to inform such processes.
Materials and Methods: Pubmed, Scopus and ISI Web of Knowledge databases were searched through the terms “industry 4.0” and “nanotechnology or nanomaterial*” and “risk assessment or risk management”, to capture relevant papers published in 2011-2021.
Results: Nanotechnology support industry 4.0 in the aerospace, automobile, construction, manufacturing, food processing, packaging and medical fields. High-tech uses include new materials for batteries, sensors and 3D printing. However, these innovations may lead to emerging occupational chemical and physical risks, and psychological risks due to mental overload and work density due to such flexible and dynamic smart nano-manufacturing activities.
Conclusions: Operational risks related to all stages of the 4.0 manufacturing processes should be identified. Safe and sustainable by design products and processes should be developed to “design out” or minimize hazards and risks for the workforce. Broad-based training and continuous professional development, including also occupational health and safety issues, should be encouraged.

Sp15-3

Implementation of a harmonized approach for monitoring exposure to engineered and incidental nanoparticles and their potential health effects: First results from the EU-LIFE project NanoExplore

Irina Guseva Canu [1], Guillaume Suarez [1], Jean-Jacques Sauvain [1], Nancy B. Hopf [1], Camille Crézé [1], Maud Hemmendinger [1], Carlos Fito [2], Giulia Squillacioti [3], Federica Ghelli [3], Martina Buglisi [3], Giacomo Garzaro [3] and Enrico Bergamaschi [3]

[1] Department of Occupational and Environmental Health, Center for Primary Care and Public Health, University of Lausanne, Lausanne,

Switzerland, [2] Instituto Tecnológico del Embalaje. Transporte y Logística, Valencia, Spain, [3] Department of Public Health and Pediatrics, University of Torino, Italy

Introduction: We aimed at validating a harmonized protocol for monitoring occupational exposure to engineered/incidental nanoparticles (EINP) and to assess their health effects.
Materials and Methods: A multicentric prospective cohort study was designed involving repeated field campaigns of 4-day exposure monitoring and two biological samplings, at the beginning (T1) and at the end (T2) of working week. To detect a significant difference in effect biomarkers of at least 25%, a sample size of 120 workers (60 exposed, 60 non-exposed) was determined, along with two control groups, internal and external to company. The protocol feasibility was tested in three countries: Switzerland, Spain, and Italy. Number and mass concentration, morphology, size distribution and surface area of EINP were measured, and effect biomarkers (oxidative stress and inflammation) were assessed in exhaled breath condensate (EBC) and/or urine samples.
Results: The preliminary results of 42 external controls showed no significant change in effect biomarker levels between T1 and T2, with the exception of malondialdehyde and 8-Isoprostane in EBC. The biomarkers levels were within the ranges reported in healthy adults. The analysis of data and samples collected in 60 exposed workers and 36 internal controls recruited at six EINP-handling facilities are ongoing.
Conclusions: These findings confirm the feasibility of the harmonized protocol. For its implementation, a particular effort on organization, coordination and communication between each team was mandatory, particularly during COVID time.

Sp15-4

Ethics and Scientific Issues of New Technologies: Lessons from Nanotechnology

Paul A. Schulte

Division of Science Integration, Centers for Disease Control and Prevention/National Institute for Occupational Safety and Health, Cincinnati, OH, United States

Introduction: In the absence of scientific clarity about the health effects of occupational exposure to new technologies it is useful to study the ethical and scientific issues that arose with the emergence of nanotechnology. In the early 2000's, nanotechnology generally entered commerce. Workers were the first to be exposed to nanomaterials in the laboratory, in production, distribution, utilization, and end of life activities.
Materials and Methods: Five criterion actions were proposed that should be practiced by decision-makers at business and societal levels if nanotechnology was to be developed responsibly (which chiefly means workers and consumers are not harmed). These could be applied to new technologies and include: (1) anticipate, identify and track potentially hazardous nanomaterials in the workplace; (2) assess workers' exposures to new technologies; (3) assess and communicate hazards and risks to workers; [(4)] manage occupational safety and health risks; and (5) foster the safe development of new technologies and realization of its societal and commercial benefits.
Results: All these criteria are necessary for responsible development of a new technology to occur.
Conclusions: In the emergent period for new technologies there are many unknowns about hazards so it is prudent to treat them all as potentially hazardous until adequate response can be provided for the 5 criterion actions.

Special Session 16 Pesticide Exposure: Understanding Pathways of Exposure and Health Outcomes to Develop Interventions to Reduce Exposure and Improve Safety

Chair: Diane Rohlman

Session introduction

Environmental and occupational exposure to pesticides is common and agricultural workers and their families are at risk. Furthermore, many children and adolescents throughout the world are engaged in agricultural work, either for pay or on family farms. Understanding the pathways and magnitude of exposure is essential to develop methods to reduce exposure and to inform regulators and policy. This session will examine the association between exposure and behavioral outcomes associated with organophosphate exposure, describe a tool to examine exposure-related risk to pesticides, and apply theoretically-based tools and interventions targeted at changing workplace behaviors and hygiene practices associated with pesticide exposure.

Sp16-1

Residential proximity to crops in relation to pesticide exposure and mental health in Ecuadorian children and adolescents: The ESPINA study

José Suarez, B.N. Chronister, G. Kayser, J. Suarez-Torres, H. Checkoway, E. Friedman and D. Martinez

Wertheim School of Public Health, University of California San Diego, H. La Jolla, USA

Introduction: Children living near agricultural crops have increased risk of chronic exposure to pesticides, which may affect neurobehavior. We characterized these associations among children and adolescents living in agricultural settings.
Materials and Methods: We examined 623 participants across 3 times between 2008-2016 (Ages: 4-9y in 2008 and 11-17y in 2016) in Ecuador. Generalized linear mixed models estimated longitudinal and cross-sectional associations of residential proximity to floricultural greenhouses with urinary pesticide metabolites, erythrocytic acetylcholinesterase (AChE), and neurobehavior (NEPSY-2), adjusting for hemoglobin, creatinine, demographic and anthropometric covariates.
Results: Residential proximity to greenhouse crops was associated with lower AChE activity (reflecting greater cholinesterase inhibitor pesticide exposure) in children living within 275 m of crops (AChE difference per 100 m of proximity [95% CI] = -0.10 U/mL [-0.20, -0.006]). Residence within 300m of crops was associated with higher urinary concentrations of para-nitrophenol (PNP), a metabolite of parathion (% difference per 100m of proximity = 8.5% [95%CI: 1.8, 14.7]), and with other pesticide metabolites. Living within 100m (vs. >500m) of crops was associated with increased odds (OR [95% CI]) of low scores for Memory/Learning (1.24 [1.05, 1.46]) and Language (1.09 [1.00, 1.19]) domains.
Conclusions: Children living near floricultural greenhouse crops had greater biomarkers of organophosphate exposures and lower neurobehavioral performance. Mitigation of off-target drift of pesticides from crops onto nearby homes is recommended.