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Marzieh Shahriyari, Davood Afshari & Seyed Mahmood Latifi. *Physical workload and musculoskeletal disorders in back, shoulders and neck among welders.* Pages: 639-645.

This study aimed to determine the effect of the physical workload on the back, neck and shoulders of welders. The prevalence of musculoskeletal symptoms was assessed using the Nordic questionnaire among 15 welders. The physical workload of the neck, back and upper arms was then measured by means of inclinometry as the welders were working. The results revealed that the highest prevalence of musculoskeletal disorders during the previous 12 months was in the lower back and shoulders. The median trunk and neck flexion were significantly associated with back and neck pain in welders with symptoms during the past year ($p < 0.05$). Physical exposure in welders with pain was characterized by significantly more awkward postures and percentage of time spent with the trunk and neck flexed more than 20° . The nature of their work and the design of their workstations may be causes of the symptoms they experienced during work.

- **Keywords:** musculoskeletal disorders, physical workload, awkward posture, welders

Leila Ibrahim Ghavamabadi, Behzad Fouladi Dehaghi, Morteza Hesampour & Kambiz Ahmadi Angali. *Application of a TiO₂ nanocomposite in earplugs: a case study of noise reduction.* Pages: 646-650.

Background. Use of hearing protection devices has become necessary when other control measures cannot reduce noise to a safe and standard level. In most countries, more effective hearing protection devices are in demand. *Objective.* The aim of this study was to examine the effects of titanium dioxide (TiO₂) nanoparticles on noise reduction efficiency in a polyvinyl chloride (PVC) earplug. *Methods.* An S-60 type PVC polymer as the main matrix and TiO₂ of 30-nm size were used. The PVC/TiO₂ nanocomposite was mixed at a temperature of 160 °C and 40 rpm and the samples were prepared with 0, 0.2 and 0.5 wt% of TiO₂ nanoparticle concentrations. *Results.* Earplug samples with PVC/TiO₂ (0.2, 0.5 wt%) nanoparticles, when compared with raw earplugs, showed almost equal noise attenuation at low frequencies (500–125 Hz). However, at high frequencies (2–8 kHz), the power of noise reduction for earplugs containing

TiO₂ nanoparticles was significantly increased. *Conclusions.* The results of the present study showed that samples containing nanoparticles of TiO₂ had more noticeable noise reduction abilities at higher frequencies in comparison with samples without the nanoparticles.

- **Keywords:** noise reduction, nanocomposite, titanium dioxide, earplug

A. Mohammed Abubakar, Himmet Karadal, Steven W. Bayighomog & Ethem Merdan. *Workplace injuries, safety climate and behaviors: application of an artificial neural network.* Pages: 651-661.

This article proposes and tests a model for the interaction effect of the organizational safety climate and behaviors on workplace injuries. Using artificial neural network and survey data from 306 metal casting industry employees in central Anatolia, we found that an organizational safety climate mitigates workplace injuries, and safety behaviors enforce the strength of the negative impact of the safety climate on workplace injuries. The results suggest a complex relationship between the organizational safety climate, safety behavior and workplace injuries. Theoretical and practical implications are discussed in light of decreasing workplace injuries in the Anatolian metal casting industry.

- **Keywords:** safety climate, safety behavior, workplace injuries, artificial neural network

Mohammad Ghasemi, Amir Hossein Khoshakhlagh, Ali Ghanjal, Saeid Yazdanirad & Fereydoon Laal. *The impacts of rest breaks and stretching exercises on lower back pain among commercial truck drivers in Iran.* Pages: 662-669.

Purpose. This study aimed to determine the impacts of rest breaks and stretching exercises on lower back pain (LBP) in commercial truck drivers. *Methods.* This quasi-experiment was carried out on 92 truck drivers suffering from chronic LBP. Subjects were categorized into three groups (stretching exercises and rest breaks, rest breaks only and reference). Pain severity and related disability were measured at the beginning of the survey and after 6 and 12 weeks. The latter was assessed using the Oswestry low back pain disability questionnaire (OLBPDQ) and the Roland Morris questionnaire (RMQ). *Results.* At the end of the intervention, the mean pain scores in the three groups were 2.72 ± 1.44 , 4.11 ± 0.86 and 4.90 ± 1.31 respectively ($p < 0.001$). The OLBPDQ scores in group 1 (stretches and resting time breaks) were significantly lower than those in group 2 (rest break) ($p = 0.009$). The RMQ scores showed a significant reduction in group 1 compared with the other two groups ($p = 0.001$). Drivers in group 2 improved more significantly than those in group 3 regarding visual analog scale pain score ($p = 0.049$), OLBPDQ score ($p = 0.024$) and RMQ score ($p = 0.011$). *Conclusion.* This study provided converging results that supplementary exercises during break periods consistently help to minimize LBP and disability.

- **Keywords:** commercial drivers, lower back pain, resting time break, stretching exercises

Mostafa Mirzaei Aliabadi, Hamed Aghaei, Omid Kalatpour, Ali Reza Soltanian & Asghar Nikravesh. *Analysis of human and organizational factors that influence mining accidents based on Bayesian network.* Pages: 670-677.

Purpose. The present study aimed to analyze human and organizational factors involved in mining accidents and determine the relationships among these factors. *Materials and*

methods. In this study, the human factors analysis and classification system (HFACS) was combined with Bayesian network (BN) in order to analyze contributing factors in mining accidents. The BN was constructed based on the hierarchical structure of HFACS. The required data were collected from a total of 295 cases of Iranian mining accidents and analyzed using HFACS. Afterward, prior probability of contributing factors was computed using the expectation-maximization algorithm. Sensitivity analysis was applied to determine which contributing factor had a higher influence on unsafe acts to select the best intervention strategy. *Results.* The analyses showed that skill-based errors, routine violations, environmental factors and planned inappropriate operation had higher relative importance in the accidents. Moreover, sensitivity analysis revealed that environmental factors, failed to correct known problem and personnel factors had a higher influence on unsafe acts. *Conclusion.* The results of the present study could provide guidance to help safety and health management by adopting proper intervention strategies to reduce mining accidents.

- **Keywords:** Bayesian network human factors analysis and classification system human error mining accident prevention

Vedant Singh & Anita Verma. *A review, simple meta-analysis and future directions of safety climate research in manufacturing organizations.* Pages: 678-704.

This article reviews 60 studies examining safety climates related to manufacturing. The study identifies several conceptual and methodological limitations associated with developing safety climate measurements, such as lack of a rigorous validation process, problematic sample sizes and composition. Within the reviewed studies, several factors were used to measure safety climates. Management commitment to safety and associated training and procedures were most common, followed by workers' attitudes and commitment. The most frequently used factors should reflect the fact that prevention of work-related accidents and injuries depends on both the organization's and workers' actions. Most studies made no attempt to establish discriminate and convergent validities of the tools used. We recommend that rather than construct more questionnaires, researchers should correlate safety climate constructs with existing safety performance metrics to establish convergent and discriminate validities. The accident rate in manufacturing industries is sufficient to measure safety performance and assess the discriminate validity of these tools.

- **Keywords:** safety climate safety culture manufacturing industry emergent themes validity

Muhammet Gul. *Application of Pythagorean fuzzy AHP and VIKOR methods in occupational health and safety risk assessment: the case of a gun and rifle barrel external surface oxidation and colouring unit.* Pages: 705-718.

The field of occupational health and safety (OHS) focuses on reducing occupational accidents to an acceptable level. OHS covers systematic efforts aimed at providing employee health, safety and welfare in the workplace. This study proposes a new approach for risk assessment in the field of OHS. It integrates the Pythagorean fuzzy analytic hierarchy process (PFAHP) and fuzzy VlseKriterijumska Optimizacija I Kompromisno Resenje (FVIKOR) into a risk assessment process. The PFAHP is used in weighting the risk parameters. FVIKOR is then applied to prioritize the hazards. To demonstrate the applicability and validity of the proposed approach, a case study of a barrel external surface oxidation and colouring unit of a gun and rifle production facility is performed. A comparison is also provided between the proposed approach and an

intuitionistic fuzzy sets-based approach. The proposed approach is found to produce reliable outcomes that better represent the vagueness of the decision-making process.

- **Keywords:** Occupational health and safety risk assessment Pythagorean fuzzy sets analytic hierarchy process fuzzy Vlsekriterijumska Optimizacija I Kompromisno Resenje gun and rifle production

Pei-Luen Patrick Rau, Pin-Chao Liao, Zhi Guo, Jian Zheng & Buyun Jing. *Personality factors and safety attitudes predict safety behaviour and accidents in elevator workers.* Pages: 719-727.

Elevator accidents happen frequently and cause much loss. Personality factors and safety attitudes have been proved effective in predicting accidents in traffic and the workplace. The present study aimed to explore the effect of personality factors and safety attitudes in elevator accidents. A survey was carried out on 383 elevator installers and repairers in China, measuring personalities (conscientiousness, agreeableness and trait anxiety), safety attitudes (compliant and proactive), safety behaviours and accidents (occupational injuries). Approximately 60% of the elevator workers had been injured in the past 6 months. The structural equation model suggested that conscientiousness could predict compliant safety behaviour both directly and indirectly through safety attitude and could predict proactive safety behaviour. Agreeableness could predict compliant safety behaviour. Trait anxiety could predict occupational injuries. Recruiters should choose elevator workers who are conscientious, agreeable and of low trait anxiety. Safety trainings for elevator workers should focus on culturing their safety attitude.

- **Keywords:** personality safety attitudes safety behaviour workplace accident workplace safety

Aaro Hazak, Erve Sõõru, Heili Hein & Kadri Männasoo. *Effects of work arrangements on the sleep regimen of creative research and development employees.* Pages: 728-739.

Traditional 'nine-to-five' working schedules do not consider individual characteristics. We identify what types of employees suffer from the adverse effects of work arrangements on their sleep regimen based on a survey of Estonian creative research and development (R&D) employees (N = 153). We present ordinary least squares and ordered probit regression estimates and recursive structural equation model estimates of the employees' perceived level of sleep regimen disruption. We find that evening-type employees, women and employees with a lower creative intensity of work perceive with a significantly higher probability that work limits their sleep, while employees having flexibility in both working time and workplace feel less impacted by work-driven constraints on their sleep regimen. Granting working time and workplace flexibility and avoiding the allocation of excessive administrative duties to creative R&D employees may have a considerable positive impact on improving their sleep, thus contributing to improving their well-being and work results.

- **Keywords:** sleep morningness-eveningness flexible work gender research and development jobs Estonia

Xinlu Sun, Heap-Yih Chong & Pin-Chao Liao. *Efficiency improvement by navigated safety inspection involving visual clutter based on the random search model.* Pages: 740-752.

Navigated inspection seeks to improve hazard identification (HI) accuracy. With a tight inspection schedule, HI also requires efficiency. However, lacking quantification of HI efficiency, navigated inspection strategies cannot be comprehensively assessed. This

work aims to determine inspection efficiency in navigated safety inspection, controlling for HI accuracy. Based on a cognitive method of the random search model (RSM), an experiment was conducted to observe the HI efficiency in navigation, for a variety of visual clutter (VC) scenarios, while using eye-tracking devices to record the search process and analyze the search performance. The results show that the RSM is an appropriate instrument, and VC serves as a hazard classifier for navigation inspection in improving inspection efficiency. This suggests a new and effective solution for addressing the low accuracy and efficiency of manual inspection through navigated inspection involving VC and the RSM. It also provides insights into the inspectors' safety inspection ability.

- **Keywords:** random search model, navigated inspection, visual clutter, inspection efficiency, construction safety, safety management

Nomfundo F. Moroe. *Occupational noise-induced hearing loss in South African large-scale mines: exploring hearing conservation programmes as complex interventions embedded in a realist approach*. Pages: 753-761.

Background. Complex interventions have been conducted in the field of public health to improve health at the individual, organizational policy or population level. In occupational audiology, hearing conservation programmes (HCPs), which are interventions to minimize or eliminate occupational noise-induced hearing loss, are currently not defined as complex interventions, despite them fitting the definition and features of complex interventions. Therefore, this study aimed to explore whether HCPs are a complex intervention, fitting the predefined criteria for complex interventions. *Method.* A qualitative, descriptive research design was conducted using three sources of data – document analysis, interviews and systematic review – to allow for triangulation. Data were collected through purposive sampling and qualitative content analysis was used. *Results.* This study confirmed that HCPs are a complex intervention founded on solid and consolidated theories. Therefore, these results paved the way for realist reviews to be conducted in the mining sector in South Africa in order to understand the mechanisms influencing the success or failure of HCPs locally. *Conclusion.* The success of HCPs in the mining sector depends on conducting contextually evidence-based evaluations such as realist reviews which can provide policy-makers with contextual evidence for why certain programmes do or do not work in certain settings.

- **Keywords:** Hearing conservation programmes, complex intervention, realist reviews, occupational noise exposure, mining industry, South Africa

Peter Jackovics. *Analysis with applied statistics of the safety use of rope rescue equipment*. Pages: 762-771.

This article presents the results of a questionnaire-based survey intended to contribute to the development of safety and security requirements for rescue operations involving rope technology, the relevant rescue methodology and the operations procedure. The article tackles a number of issues that highlight the relevant criteria for choosing the proper rope-technology equipment to be used. The completed questionnaires have been assessed with various statistical tests, showing which criteria should be used as requirements by the rescue teams when selecting the safest possible rope-technology equipment. The importance of the article is emphasized by the fact that it discusses a safety technology topic that is getting relatively less attention, although it is a rather important matter for rescue in emergency situations.

- **Keywords:** usability, rope technology, questionnaire survey, carabiner, descender, ascender, Spearman's correlations

Kwan Woo Kim. *Costs of injuries and ill health in the workplace in South Korea*. Pages: 772-779.

Industrial accidents affect the sustainable development of any country, enterprise or individual. This study estimated the costs of loss due to industrial accidents in South Korea in 2013, based on the 4th Korean Working Conditions Survey. The total costs of loss were estimated at USD 27,224 million, with individuals losing the most at 79.5%, followed by employers at 20.4% and the government at 0.1%. These costs were equivalent to 2.1% of South Korea's gross domestic product in 2013. The costs to society/death due to industrial accidents were USD 640,000; USD 7000/individual out of work for ≤ 3 days and USD 242,000/individual out of work for ≥ 4 days. These costs make it easy to calculate losses incurred due to industrial accidents. Costs of loss can also be used by the government as basic data to establish industrial safety and health policies.

- **Keywords:** costs of loss accidents workplace injuries work-related ill health South Korea

Chukwunedum Uzor & Sunday Ayoola Oke. *A model to predict and optimize machine guarding operator compliance activities in a bottling process plant: a developing country experience*. Pages: 780-801.

Introduction. The accurate tracking, elimination and control of hazards are fundamentals in accident avoidance at operational machine guarding stations. This article develops a machine guard usage compliance model. Nonetheless, very few studies account for operator compliance to the usage of machine guards in workplaces. *Methods.* This article contributes by first building up a multiple regression (MR) model, and, second, proposing a novel integrated MR and Taguchi method (MR-TM) model that optimizes operator compliance to guard usage. The comparative significance of the diverse factors was appraised and examined via analysis of variance. *Results.* Bottling process data from Nigeria illustrate the effectiveness of the proposed model. The coefficient of determination ($R^2 = 0.997$) established the efficient predictive ability of the MR model. The significant variables are the number of functional guards and damaged guards, and the number of non-compliances (guards present and operational but not used) ($p < 0.050$). Simulated and field data variables exhibited good agreement ($R^2 = 0.997$). From the MR-TM model, the most significant result is the highest operator compliance for machine guard usage with mean and signal-to-noise ratio values of 269.28 and 48.60, respectively. *Conclusion.* This work provides safety managers with snapshot information for planning and control purposes.

- **Keywords:** safety, hazards, process plant, manufacturing, risk

Danying Zhang, Maosheng Yan, Hansheng Lin, Guoyong Xu, Hua Yan & Zhipeng He. *Evaluation of work-related musculoskeletal disorders among sonographers in general hospitals in Guangdong province, China*. Pages: 802-810.

Introduction. Research on the prevalence of and potential risk factors associated with work-related musculoskeletal disorders (WMSDs) among sonographers in China is scarce. More evidence is required to mitigate WMSDs among sonographers in Guangdong province, China. *Objective.* The present study aimed to determine the prevalence of and potential associated factors for WMSDs among sonographers in general hospitals in Guangdong province, China. *Methods.* A self-reported questionnaire was distributed to sonographers from 14 general hospitals selected by convenience sampling in Guangdong province. Multivariate logistic regression was used to analyze associations between potential factors and WMSDs in the most affected body areas. *Results.* In this study, 249 sonographers completed the questionnaire, yielding a response rate of 75.5%. The 12-

month period prevalence of WMSDs was 95.2%, and the four most affected regions were the right shoulder (81.1%) followed by the neck (74.7%), right wrist/hand (59.4%) and lower back (57.0%). Among symptomatic sonographers, 31.2% were absent from work. Gender, years of experience, number of patients per day, shift type and lumbar support were associated with WMSDs in the most affected regions. *Conclusion.* Lower workload, more regular rest breaks and good ergonomics of working conditions are encouraged to alleviate WMSDs among sonographers in Guangdong province.

- **Keywords:** ergonomics, musculoskeletal disorders, sonographers

Akeem Pedro, Hai Chien Pham, Jung Ui Kim & Chansik Park. *Development and evaluation of context-based assessment system for visualization-enhanced construction safety education.* Pages: 811-823.

Construction jobsites remain among the most dangerous workplaces, with fatalities, accidents and injuries still plaguing the industry. Safety education is critical in fostering graduates capable of ensuring safe construction work; however, current learner assessment methods in pedagogy fail to ascertain the possession of safety knowledge and skills as they would be required in practice. This article aims to address this problem by proposing context-based learner assessment in construction safety education. A novel assessment system is developed and deployed with final-year construction management students, with learner testing through visualization-enhanced safety theory questions, site inspection scenario questions and job safety analysis review questions. The cognitive impact of the assessment approach is investigated through the NASA task load index, and its effectiveness is verified through educator and learner trials. Results demonstrate that the proposed system has significant potential as an innovative assessment tool for safety education.

- **Keywords:** construction safety, safety education, virtual reality, assessment, context-based

Pierre Nanyan & Mondher Ben Charrada. *Compensation claims for work-related musculoskeletal disorders among hairdressers in France, 2010–2016.* Pages: 824-828.

Background. Hairdressers in France experience occupational illness as well as stressful working conditions which can result in permanent incapacity mainly due to work-related musculoskeletal disorders (WRMSDs), yet WRMSDs in this workforce remain largely unstudied. *Objective.* The aim of this study was to analyze trends in compensation claims for WRMSDs among hairdressers. *Methods.* Data concerning gender, age, permanent incapacity, working experience and lost work days (LWD) of claimants were extracted from the French National Health Insurance Fund for Salaried Workers. *Results.* The claim rate increased non-significantly by 12.8% during the study period. The incidence rate of permanent incapacity increased significantly by 16.0%. In proportion, significant differences were observed between age groups, with age 35–49 years ranking first (45.8%), and also in claimants with working experience > 10 years (43.1%). Overall, there were 666,461 LWD during the study period with a significant increase of 16.2% ($p < 0.001$). *Conclusion.* Although the claims rate did not increase significantly, the incidence rate of permanent incapacity increased significantly and some groups at risk have been identified.

- **Keywords:** Occupational illness, workers, permanent incapacity, sickness absence, working experience

Sepehr Alizadehsalehi, Ibrahim Yitmen, Tolga Celik & David Arditi. *The effectiveness of an integrated BIM/UAV model in managing safety on construction sites.* Pages: 829-844.

Introduction. A variety of approaches exist to achieve better construction safety performance, but only a few consider a combination of building information modeling (BIM) and unmanned aerial vehicles (UAVs). *Method.* This article presents a four-dimensional (4D) BIM/UAV-enabled safety management model based on IDEF0 language. In the first step, potential hazards are identified with the help of safety specialists' experiences and BIM software used in the design of the structure. Then, a UAV monitors the location of the potential hazards. The third step involves the integration of the 4D BIM-based model and the information obtained from the UAV. Finally, the combined data are analyzed and interpreted, and site safety staff are notified about measures to be put in place to prevent accidents. *Results.* This model shows a strong relationship between the design and construction phases by using BIM in the design phase and UAVs in the construction phase. The proposed safety model was evaluated by construction safety specialists in a two-pronged approach. *Conclusion.* The number of fatal, non-fatal and property damage-causing accidents may be significantly lower when the proposed system was used. *Practical application.* This model allows safety specialists to identify hazards and develop suitable mitigation strategies.

- **Keywords:** construction safety management, four-dimensional visualization, building information modeling, unmanned aerial vehicles