

IWH Research Alert
April 5, 2019

Missed an issue? Catch up on previous *Research Alerts* available on the IWH website <https://www.iwh.on.ca/journal-articles/research-alerts>

Research Alert is a service provided to you by the Institute for Work & Health (IWH) to help you keep abreast of recent literature in the areas of occupational health and safety, epidemiology, public health and others within the IWH mandate. Please note that these articles have not been reviewed by Institute scientists to assess the quality of the studies. *Research Alerts* should not be considered an endorsement of the findings. Readers are cautioned not to act on the results of single studies, but rather to seek bodies of evidence. It should also be noted that the Institute for Work & Health cannot provide full-text of articles listed in *Research Alerts* to individuals outside of the organization, as this violates copyright legislation.

Aasdahl L, Gismervik SO, Marchand GH, Vasseljen O, Johnsen R, and Fimland MS. Changes in fear-avoidance beliefs and work participation after occupational rehabilitation for musculoskeletal- and common mental disorders: secondary outcomes of two randomized clinical trials. *Journal of Rehabilitation Medicine*. 2019; 51(3):175-182.

<https://doi.org/10.2340/16501977-2520> [open access]

Abstract: OBJECTIVES: To assess: (i) whether changes in the Fear-Avoidance Beliefs Questionnaire (FABQ) were greater for multicomponent inpatient rehabilitation vs outpatient cognitive behavioural therapy, and (ii) whether baseline scores and changes (pre- to post-intervention) in FABQ were associated with future work-participation. METHODS: Individuals sick-listed for 2-12 months were randomized to inpatient multicomponent rehabilitation (3.5 weeks or 4+4 days) or outpatient cognitive behavioural therapy (6 sessions/6 weeks). RESULTS: A total of 334 subjects were included. There were no significant differences on FABQ between the in- and out-patient programmes during follow-up. Participants with consistently low scores on the work subscale had more work-participation days, followed by those who reduced their scores. Participants who increased, or had consistently high scores had the least workdays. For the physical activity subscale, the associations were weaker.

FABQ-work scores at baseline were associated with number of work-participation days for both musculoskeletal and psychological diagnoses, and more strongly for the latter group. **CONCLUSION:** This study suggests that FABQ could be a useful prognostic tool for individuals on sick leave due to musculoskeletal or psychological disorders. There was no evidence that inpatient occupational rehabilitation reduces FABQ scores more than outpatient cognitive behavioural therapy

Durand Z, Nechuta S, Krishnaswami S, Hurwitz EL, and McPheeters M. Prescription opioid use by injured workers in Tennessee: a descriptive study using linked statewide databases. *Annals of Epidemiology*. 2019; 32:7-13.

<https://doi.org/10.1016/j.annepidem.2019.02.001> [open access]

Abstract: **PURPOSE:** This is the first study in Tennessee to measure opioid use in injured workers and among the first nationally to use a prescription drug monitoring program to do so. We conducted a retrospective cohort study to evaluate the prevalence of opioid use after injury and associated characteristics among workers reporting one injury to Tennessee Workers' Compensation. **METHODS:** Injured workers identified in Workers' Compensation records 2013-2015 were linked to their prescription history in Tennessee's prescription drug monitoring database. **RESULTS:** Among 172,256 injured workers, the prevalence of receiving an opioid after injury was 22.8% in 1 week, 29.7% in 1 month, and 33.3% in 6 months. Receiving an opioid was associated with having a fracture (odds ratio, 4.9; 95% confidence interval, 4.64-5.11 vs. other injuries). Hydrocodone short-acting was the most commonly received opioid (69.5% of injured workers), and the mean of each worker's maximum dose was 42.8 morphine milligram equivalents (SD 39.26). Ten percent of injured workers who received opioids also received a benzodiazepine. **CONCLUSIONS:** Injured workers have a high prevalence of opioid use after injury, but prescribing patterns generally tend to follow Tennessee prescribing guidelines

Gonzalez G and Vives A. Work status, financial stress, family problems, and gender differences in the prevalence of depression in Chile. *Annals of Work Exposures and Health*. 2019; 63(3):359-370.

<https://doi.org/10.1093/annweh/wxy107>

Abstract: **INTRODUCTION:** It is widely known that women have a higher prevalence of depression than men. These differences may be explained by social differences between women and men due to gender roles. In Chile, as elsewhere, women have greater household responsibilities, lower job incomes, and especially low labor market participation. However, the incidence of these gender differences on the higher prevalence of depression in women requires further study in the Chilean context. **OBJECTIVE:** To identify main social differences between women and men associated with gender differences in the prevalence of depression in middle-aged Chilean men and women. **DATA SOURCE:** Data comes from the second Chilean National Health Survey (2009-2010), a cross-sectional, nationally representative sample (n = 2771) composed of 1103 men and 1668 women (39.8 and 60.2%, respectively), whose age range goes from 25 to 55 years old. This study was approved by the Ethics Committee of Pontificia Universidad Catolica de Chile. **METHODS:** Prevalence ratios were calculated through Poisson regression models to estimate associations between the prevalence of past episodes of depression and social stressful life events variables for men and women separately. Gender prevalence ratios of depression (Gender PR) adjusted for age and subsequently adjusted by the social and stressful life events variables. The analyses considered factors such as age, educational level, per-capita household income, work status, role as the head of household, marital status, events of violence, family problems, personal health problems or accidents, and self-reported financial stress. **RESULTS:** This study finds that doing housework, reporting a serious family problem and having high financial stress were associated with a higher prevalence of depression in both genders. Whereas, health problems were only associated with prevalence in men. The age-adjusted gender PR was 2.84 [confidence interval (CI): 2.0-4.1], and when all selected variables were included attenuated to a PR of 1.86 (CI 1.3-2.7). The variable most strongly associated with depression in the fully-adjusted model was housework (PR: 5.3; CI: 1.3-21.0). **CONCLUSION:** In conclusion, this study finds that depression in Chile is associated with social factors such as participation in housework, family problems, and financial stress, all of which are more common in women. To make further progress in the study of

this public health problem in Chile, it is essential to incorporate more detailed characterization of gender roles in surveys and other studies. Likewise, social policies and interventions that contribute to reduce gender social inequalities in the exposure to adverse life circumstances can contribute to reduce unnecessary and avoidable gender disparities in health

Gouin MM, Coutu MF, and Durand MJ. Return-to-work success despite conflicts: an exploration of decision-making during a work rehabilitation program. Disability and Rehabilitation. 2019; 41(5):523-533.

<https://doi.org/10.1080/09638288.2017.1400592>

Abstract: PURPOSE: Collective decision-making by stakeholders appears important to return-to-work success, yet few studies have explored the processes involved. This study aims to explore the influence of decision-making on return-to-work for workers with musculoskeletal or common mental disorders. METHOD: This study is a secondary analysis using data from three earlier multiple-case studies that documented decision-making during similar and comparable work rehabilitation programs. Individual interviews were conducted at the end of the program with stakeholders, namely, the disabled workers and representatives of health care professionals, employers, unions and insurers. Verbatims were analysed inductively. RESULTS: The 28 decision-making processes (cases) led to 115 different decisions-making instances and included the following components: subjects of the decisions, stakeholders' concerns and powers, and types of decision-making. No differences were found in decision-making processes relative to the workers' diagnoses or return-to-work status. However, overall analysis of decision-making revealed that stakeholder agreement on a return-to-work goal and acceptance of an intervention plan in which the task demands aligned with the worker's capacities were essential for return-to-work success. CONCLUSION: These results support the possibility of return-to-work success despite conflictual decision-making processes. In addition to facilitating consensual decisions, future studies should be aimed at facilitating negotiated decisions. Implications for rehabilitation Facilitating decision-making, with the aim of obtaining agreement from all stakeholders on a return-to-work goal and their acceptance of an intervention plan that respects the

worker's capacities, is important for return-to-work success. Rehabilitation professionals should constantly be on the lookout for potential conflicts, which may either complicate the reach of an agreement between the stakeholders or constrain return-to-work possibilities. Rehabilitation professionals should also be constantly watching for workers' and employers' return-to-work concerns, as they may change during work rehabilitation, potentially challenging a reached agreement

Hanvold TN, Kines P, Nykanen M, Thomee S, Holte KA, Vuori J, et al. Occupational safety and health among young workers in the Nordic countries: a systematic literature review. *Safety and Health at Work*. 2019; 10(1):3-20.

<https://doi.org/10.1016/j.shaw.2018.12.003> [open access]

Abstract: This review aimed to identify risk factors for occupational accidents and illnesses among young workers in the Nordic countries and to attain knowledge on specific vulnerable groups within the young working force that may need special attention. We conducted a systematic review from 1994 to 2014 using five online databases. Of the 12,528 retrieved articles, 54 met the review criteria and were quality assessed, in which data were extracted focusing on identifying occupational safety, health risk factors, and vulnerable groups among the young workers. The review shows that mechanical factors such as heavy lifting, psychosocial factors such as low control over work pace, and organizational factors such as safety climate are all associated with increased injury risk for young Nordic workers. Results show that exposures to chemical substances were associated with skin reactions, e.g., hand eczema. Heavy lifting and awkward postures were risk factors for low back pain, and high job demands were risk factors for mental health outcomes. The review identified young unskilled workers including school drop-out workers as particularly vulnerable groups when it comes to occupational accidents. In addition, apprentices and young skilled workers were found to be vulnerable to work-related illnesses. It is essential to avoid stereotyping young Nordic workers into one group using only age as a factor, as young workers are a heterogeneous group and their vulnerabilities to occupational safety and health risks are contextual. Politicians, researchers, and practitioners should account

for this complexity in the education, training and organization of work, and workplace health and safety culture

Jakobsen MD, Aust B, Kines P, Madeleine P, and Andersen LL. Participatory organizational intervention for improved use of assistive devices in patient transfer: a single-blinded cluster randomized controlled trial. *Scandinavian Journal of Work, Environment & Health*. 2019; 45(2):146-157.

<https://doi.org/10.5271/sjweh.3769>

Abstract: Objectives This randomized controlled trial (RCT) evaluated the effect of a participatory organizational intervention for improved use of assistive devices (AD) in patient transfer. Methods We randomly allocated 27 departments from five hospitals in Denmark to a participatory intervention (14 clusters, 316 healthcare workers) or a control group (13 clusters, 309 healthcare workers). The intervention consisted of 2x2 hour workshops with managers, the hospital's health and safety staff, and 2-5 healthcare workers from each department. Based on an assessment of barriers and solutions conducted prior to randomization, participants developed an action plan for implementing department-specific solutions for improving the use of AD. Use of necessary AD (using digital counters as primary outcome), and general use of AD (using accelerometers as secondary outcome), pain intensity in the low-back, work-related back injuries during patient transfer, and communication and guidance in the use of AD were measured at baseline, 6 and 12 months. Results Use of necessary AD (primary outcome), low-back pain, and back injuries did not change in the intervention compared with control group at 12-month follow-up. However, general use of AD measured with accelerometers as well as communication and guidance improved significantly in the intervention versus control group. Conclusion The intervention did not result in more frequent use of the necessary AD but led to more general use of AD, as well as increased communication and guidance

Katz LF and Krueger AB. The rise and nature of alternative work arrangements in the United States, 1995–2015. *ILR Review*. 2018; 72(2):382-416.

<https://doi.org/10.1177/0019793918820008>

Kokkinen L, Kouvonen A, Buscariolli A, Koskinen A, Varje P, and Vaananen A. Human service work and long-term sickness absence due to mental disorders: a prospective study of gender-specific patterns in 1,466,100 employees. *Annals of Epidemiology*. 2019; 31:57-61.

<https://doi.org/10.1016/j.annepidem.2018.12.006>

Abstract: PURPOSE: The aim of the study was to investigate sickness absence due to mental disorders in human service occupations. METHODS: Participants (n = 1,466,100) were randomly selected from two consecutive national 9-year cohorts from the Statistics Finland population database; each cohort represented a 33% sample of the Finnish population aged 25-54 years. These data were linked to diagnosis-specific records on receipt of sickness allowance, drawn from a national register maintained by the Social Insurance Institution of Finland, using personal identification numbers. RESULTS: Sociodemographic-adjusted hazard ratios (HRs) for sickness absence due to mental disorders in all human service occupations combined were 1.76 for men (95% confidence interval [CI], 1.70-1.84) and 1.36 for women (95% CI, 1.34-1.38) compared with men and women in all other occupations, respectively. Of the 15 specific human service occupations, compared with occupations from the same skill/education level without a significant human service component, medical doctors, psychologists, and service clerks were the only occupations with no increased hazard for either sex, and the HRs were highest for male social care workers (HR 3.02; 95% CI, 2.67-3.41). CONCLUSIONS: Most human service occupations had an increased risk of sickness absence due to mental disorders, and the increases in risks were especially high for men

Laal F, Pouyakian M, Madvari RF, Khoshakhlagh AH, and Halvani GH. Investigating the impact of establishing integrated management systems on accidents and safety performance indices: a case study. *Safety and Health at Work*. 2019; 10(1):54-60.

<https://doi.org/10.1016/j.shaw.2018.04.001>

Abstract: Background Increasing the establishment of integrated management systems (IMs) is done with the purpose of leaving traditional management methods and replacing them with modern management methods. Thus, the present study sought to analyze the

events and investigate the impact of IMS on health and safety performance indices in an Iranian combined cycle power plants. **Methods** This case study was conducted in 2012 in all units of the Yazd Combined Cycle Power Plant on accident victims before and after the implementation of IMS. For data analysis and prediction of indices after the implementation of IMS, descriptive statistics and Kolmogorov–Smirnov test, Chi-square, linear regression, and Cubic tests were conducted using SPSS software. **Results** The number of people employed in the power plant in an 8-year period (2004–2011) was 1,189, and 287 cases of work-related accidents were recorded. The highest accident frequency rate and accident severity rate were in 2004 (32.65) and 2008 (209), respectively. Safe T-score reached to below -3 during 2010–2011. In addition, given the regression results, the relation between all predictor variables with outcomes was significant ($p < 0.05$), except for the variable X1 belonging to the accident severity rate index. **Conclusion** The implementation of safety programs especially that of IMS and its annual audits has had a significant impact on reducing accident indices and improving safety within the study period. Accordingly, health and safety management systems are appropriate tools for reducing accident rate, and the use of regression models and accident indices is also a suitable way for monitoring safety performance.

Larsen AK, Thygesen LC, Mortensen OS, Punnett L, and Jorgensen MB. The effect of strengthening health literacy in nursing homes on employee pain and consequences of pain: a stepped-wedge intervention trial. *Scandinavian Journal of Work, Environment & Health*. 2019; [Epub ahead of print].

<https://doi.org/10.5271/sjweh.3801> [open access]

Abstract: Objective This study examined the effectiveness of a workplace health literacy intervention on pain intensity, bothersomeness of pain, and sickness absence. **Methods** The quasi-experimental stepped-wedge cluster trial evaluated an intervention with two elements: (i) courses for employees and management to organize a joint foundation of knowledge about pain prevention and management with communication tools, and (ii) structured dialogs between employee and supervisor, to develop action plans to prevent and reduce pain. Monthly measurements were taken of pain intensity (0-10 scale), bothersomeness (days/month), and pain-related

absence (days/month). Results Six workplaces were recruited, and 88% of employees (509) participated in evaluations. At baseline, mean pain level was 4.0, mean bothersomeness was 3.8 days/month, and mean pain-related absence was 0.6 days/month. From linear mixed models, pain intensity was reduced by -0.28 [95% confidence interval (CI) -0.52- -0.04] corresponding to a 7% reduction. For employees with pain >3 at baseline, the reduction was -0.74 (95% CI -1.11- -0.38) or 12%. There was no significant mean change in bothersomeness or sickness absence among all employees. Conclusion This intervention was both feasible and effective in shifting the overall mean pain level downwards for the entire population by 7%, with an accentuated effect among employees with pain levels >3. Organizing health literacy in nursing homes might be a feasible and effective way to build work environment efforts targeting the needs of employees. Future studies should investigate whether organizing health literacy is effective in other workplace settings and for employees with other health challenges

Loef B, van Baarle D, van der Beek AJ, Sanders EAM, Bruijning-Verhagen P, and Proper KI. Shift work and respiratory infections in health-care workers. American Journal of Epidemiology. 2019; 188(3):509-517.

<https://doi.org/10.1093/aje/kwy258> [open access]

Abstract: Recently, there has been interest in whether shift work may enhance susceptibility to infection. Our aim was to determine whether shift workers in the health-care field have a higher incidence, duration, and/or severity of influenza-like illness (ILI) and acute respiratory infection (ARI) than non-shift workers. From September 2016 to June 2017, 501 rotating and/or night-shift workers and 88 non-shift workers from the Klokwerk+ Study (the Netherlands, 2016-2017) registered the occurrence of ILI/ARI symptoms daily using a smartphone application. The incidence rate of ILI/ARI (defined as ≥ 2 symptoms on the same day/ ≥ 1 symptom on 2 consecutive days), the mean duration of each episode, and the incidence rate of severe episodes were compared between shift workers and non-shift workers using negative binomial regression and linear mixed-model analysis. In total, participants completed 110,347 diaries. Shift workers' incidence rate of ILI/ARI was 1.20 (95% confidence interval

(CI): 1.01, 1.43) times higher than that of non-shift workers, and for severe ILI/ARI episodes, shift workers' incidence rate was 1.22 (95% CI: 1.01, 1.49) times higher. The mean duration of an ILI/ARI episode did not differ (ratio between means = 1.02, 95% CI: 0.87, 1.19). In conclusion, shift workers in health care had more ILI/ARI episodes and more severe ILI/ARI episodes than non-shift workers, but with a similar duration. Insight into underlying mechanisms connecting shift work and infection susceptibility will contribute to the design of preventive initiatives

Newaz MT, Davis P, Jefferies M, and Pillay M. Using a psychological contract of safety to predict safety climate on construction sites. Journal of Safety Research. 2019; 68:9-19.

<https://doi.org/10.1016/j.jsr.2018.10.012>

Abstract: INTRODUCTION: The fact that safety climate impacts safety behavior and delivers better safety outcomes is well established in construction. However, the way workers safety perception is inclined and developed is still unclear. METHOD: In this research, the influence of supervisors' developing safety climate and its impact on workers' safety behavior and their conceptualization of safety is explored through the lens of the 'Psychological Contract' (PC). More specifically, it is argued that 'Psychological Contract of Safety' (PCS) is a vital factor in explaining how workers attach meaning to a supervisor behavior. Extant research suggests: (a) safety climate is based on the perception of workers regarding safety; and (b) PCS is based on perceived mutual obligations between workers and supervisors. As a result, this research argues that if PCS or mutual obligations between workers and supervisors are fulfilled, then safety climate of the workers will be positively influenced. A model is presented depicting PCS as an alternative intervention in understanding how safety climate could be influenced and predicted by the level of fulfillment of mutual safety obligations. Using Structural Equation Modeling (SEM) the model of the PCS is validated with data collected from a mega-construction project in Australia. RESULTS: The results suggest that to have a positive and strong safety climate, top-level managers must ensure that mutual safety obligations between supervisor and workers are fulfilled. This enables the PCS to be introduced as a new 'predictor' of safety climate. Practical applications: The novel outcome of the research could be considered

as a management intervention to modify supervisors' behavior to produce better safety outcomes

Norstedt M. Work and invisible disabilities: practices experiences and understandings of (non)disclosure. Scandinavian Journal of Disability Research. 2019; 21(1):14-24. <https://doi.org/10.16993/sjdr.550> [open access]

Abstract: Invisible disabilities involve dilemmas that differentiate them from visible disabilities. However, little is known about the situation persons with invisible disabilities face at work, as empirical studies are scarce. The present article contributes in-depth knowledge of practices, experiences and understandings that affect the work situation for people with invisible disabilities in a Swedish context. The article draws on qualitative, in-depth interviews with 10 persons with invisible disabilities and seven persons who – in their professional work as employers, HR managers, medical doctors or psychologists in the occupational healthcare – regularly have dealings with persons with invisible disabilities. The analysis shows how practices, experiences and understandings regarding disclosure differ between the two groups of informants – differences that lead to dilemmas for the persons with invisible disabilities. These results indicate that persons with invisible disabilities are in a vulnerable position despite the fact that working life in Sweden is relatively well-regulated.

Parsons R, Golder S, and Watt I. More than one-third of systematic reviews did not fully report the adverse events outcome. Journal of Clinical Epidemiology. 2019; 108:95-101. <https://doi.org/10.1016/j.jclinepi.2018.12.007> [open access]

Abstract: OBJECTIVES: The aim of the study was to assess the risk for adverse events reporting bias in systematic reviews of health care interventions registered to PROSPERO. STUDY DESIGN AND SETTING: This study was a retrospective cohort study. Systematic review protocols in PROSPERO were screened and included if they focused on a health care intervention and listed an adverse event as either a primary or secondary outcome. The included systematic reviews were assessed to determine the completeness of reporting for the adverse event outcomes. Any discrepancies in reporting between protocol and review were recorded. RESULTS: Of 1,376

protocols for systematic reviews sifted, only 524 (38%) listed adverse events outcomes. One hundred eighty-six protocols were published in 2017 and 2018, of which 146 were included in our analysis. Among the included systematic reviews, 65% (95/146) fully reported the adverse event outcomes as intended by the protocol, 8% (12/146) entirely excluded the adverse event outcome, and the remaining 27% (39/146) either partially reported or changed the adverse event outcomes. CONCLUSION: Sixty-two percent of reviews did not mention adverse events in their protocol, and 35% of PROSPERO-registered systematic reviews had discrepant outcome reporting between the protocol and publication. The findings suggest a need for the encouraged use of harms reporting guidelines and further research into adverse events reporting bias

Stahl C, Seing I, Gerdle B, and Sandqvist J. Fair or square? Experiences of introducing a new method for assessing general work ability in a sickness insurance context. Disability and Rehabilitation. 2019; 41(6):656-665.

<https://doi.org/10.1080/09638288.2017.1401675>

Abstract: PURPOSE: To study social validity and perceived fairness of a new method for assessing general work ability in a sickness insurance context. Assessments are based on self-reports, combined with examinations by physicians, and, if needed, occupational therapists, physiotherapists and/or psychologists. MATERIALS AND METHODS: Interviews with 36 insurance officials, 10 physicians, and 36 sick-listed persons, which were analysed through a qualitative content analysis. RESULTS: Insurance officials and physicians considered the method useful and that it facilitated benefit decisions. The experiences of persons who had undergone the assessment differed, where the dialog with insurance officials seemed to have had an influence on experiences of the assessment and the decisions it led to. CONCLUSIONS: The perceived fairness and social validity of the assessment depended on how it was carried out; organisational conditions and priorities; communication skills; and decision outcomes. Professionals have an important pedagogical task in explaining the purpose and procedure of the assessment in order for the sick-listed to perceive it as fair rather than square, i.e., too standardised and not considering individual conditions. If the assessment could be used also for rehabilitative purposes, it could

possibly be perceived as more acceptable also in cases where it leads to denied benefits. Implications for rehabilitation The perceived fairness of work ability assessments is dependent on procedures for the assessment, communication with the person, and the outcome. What is considered fair differs between assessing professionals and persons being assessed. Professionals may influence the perceptions of fairness through their way of communication. Assessments need to be coupled with rehabilitation measures in order to be perceived as relevant and acceptable

Tatsuse T, Sekine M, and Yamada M. The contributions made by job satisfaction and psychosocial stress to the development and persistence of depressive symptoms: a 1-year prospective study. Journal of Occupational & Environmental Medicine. 2019; 61(3):190-196.

<https://doi.org/10.1097/JOM.0000000000001491>

Abstract: OBJECTIVE: The purpose of this study was to determine the factors that contributed to the development and persistence of depression over the course of 1 year in work environment.

METHODS: The subjects were 992 Japanese civil servants aged between 19 and 65 years. Baseline data and linked with data collected at 1-year follow up. **RESULTS:** After adjusting for baseline depression levels, job satisfaction, and work-related psychosocial stress (job control and job demand) were significantly related to depression at 1-year follow up. Moreover, those who reported job dissatisfaction were at higher risk of developing depression (odds ratios [ORs]: 1.94) and persistent depression associated with low job control (ORs: 2.64) and high job demand (ORs: 2.20).

CONCLUSIONS: Job satisfaction, and psychosocial stress at baseline predicted development of and recovery from depression at 1-year follow up, respectively

Warshaw EM, Schlarbaum JP, Silverberg JI, DeKoven JG, Maibach HI, Sasseville D, et al. Safety equipment: when protection becomes a problem. Contact Dermatitis. 2019; [Epub ahead of print].

<https://doi.org/10.1111/cod.13254>

Zuidema C, Sousan S, Stebounova LV, Gray A, Liu X, Tatum M, et al. Mapping occupational hazards with a multi-sensor network in a heavy-vehicle manufacturing facility. *Annals of Work Exposures and Health*. 2019; 63(3):280-293.

<https://doi.org/10.1093/annweh/wxy111>

Abstract: Due to their small size, low-power demands, and customizability, low-cost sensors can be deployed in collections that are spatially distributed in the environment, known as sensor networks. The literature contains examples of such networks in the ambient environment; this article describes the development and deployment of a 40-node multi-hazard network, constructed with low-cost sensors for particulate matter (SHARP GP2Y1010AU0F), carbon monoxide (Alphasense CO-B4), oxidizing gases (Alphasense OX-B421), and noise (developed in-house) in a heavy-vehicle manufacturing facility. Network nodes communicated wirelessly with a central database in order to record hazard measurements at 5-min intervals. Here, we report on the temporal and spatial measurements from the network, precision of network measurements, and accuracy of network measurements with respect to field reference instruments through 8 months of continuous deployment. During typical production periods, 1-h mean hazard levels +/- standard deviation across all monitors for particulate matter (PM), carbon monoxide (CO), oxidizing gases (OX), and noise were 0.62 +/- 0.2 mg m⁻³, 7 +/- 2 ppm, 155 +/- 58 ppb, and 82 +/- 1 dBA, respectively. We observed clear diurnal and weekly temporal patterns for all hazards and daily, hazard-specific spatial patterns attributable to general manufacturing processes in the facility. Processes associated with the highest hazard levels were machining and welding (PM and noise), staging (CO), and manual and robotic welding (OX). Network sensors exhibited varying degrees of precision with 95% of measurements among three collocated nodes within 0.21 mg m⁻³ for PM, 0.4 ppm for CO, 9 ppb for OX, and 1 dBA for noise of each other. The median percent bias with reference to direct-reading instruments was 27%, 11%, 45%, and 1%, for PM, CO, OX, and noise, respectively. This study demonstrates the successful long-term deployment of a multi-hazard sensor network in an industrial manufacturing setting and illustrates the high temporal and spatial resolution of hazard data that sensor and monitor networks are capable of. We show that network-derived hazard measurements

offer rich datasets to comprehensively assess occupational hazards. Our network sets the stage for the characterization of occupational exposures on the individual level with wireless sensor networks