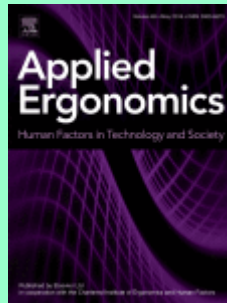


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Peter Simeonov, Hongwei Hsiao, Thomas Armstrong, Qianyi Fu, Charles Woolley, Tsui-Ying Kau. [Effects of aerial ladder rung spacing on firefighter climbing biomechanics](#). 102911.

This study investigated the effects of aerial ladder rung spacing on firefighter climbing biomechanics. Ten female and 9 male firefighters ascended and descended instrumented ladders with rungs spaced at 356 mm (current design) and 305 mm in a laboratory setup. The climbing tests were performed at five ladder slope and handrail conditions: 30° with low (305 mm) and high (914 mm) handrails, 52.5° with and without a low handrail, and 75° without a handrail. Foot and hand forces and body movements were recorded and used to calculate joint moments of the upper and lower body. Reduced rung spacing resulted in reduced foot forces, reduced hand forces, and reduced ankle transverse moment. It was also associated with increased climbing speed for female climbers, and increased ankle vertical overshoot. The results indicate that reduced rung spacing on aerial ladders may lead to lower biomechanical stress; better climbing efficiency and safety; and reduced climbing speed disparity across sexes.

- **Keywords:** Aerial ladder; Rung spacing; Climbing biomechanics

Steven A. Lavender, Carolyn M. Sommerich, Steven Bigelow, Eric B. Weston, Kelly Seagren, Noura Amini Pay, Dawn Sillars, Vivek Ramachandran, Chunyi Sun, Yilun Xu, William S. Marras. [A biomechanical evaluation of potential ergonomic solutions for use by firefighter and EMS providers when lifting heavy patients in their homes](#). 102910.

Firefighters and EMS providers continue to be challenged when lifting heavy patients in their homes. This study investigated the biomechanical efficacy of four devices that could be used by two-person teams when lifting patients from the floor, from a reclining chair, or from a Simulated Inflatable Seat at chair height. Fourteen firefighter-paramedics, working in two-person teams, were instrumented with motion capture and electromyographic sensors. The Binder Lift™, the Simple Strap, and the Slip Preventer were used to lift patient actors, and were compared to current lifting methods. Postural data and the peak dynamic spine shear forces at the L5/S1 level were reduced when using the Simple Strap, the Binder Lift, and the Simulated Inflatable Seat. The Slip Preventer reduced spine flexion when the Binder Lift was not used. In summary, the tested devices can potentially reduce the biomechanical loads experienced by EMS providers as they lift and move patients.

- **Keywords:** Firefighter; EMS; Ergonomics; Patient handling; Injury prevention

Pierre Berastegui, Mathieu Jaspar, Alexandre Ghuysen, Anne-Sophie Nyssen. [*Fatigue-related risk perception among emergency physicians working extended shifts.*](#) **102914.**

There is a growing body of studies indicating that extended shift duration has an adverse effect on fatigue, consequently leading to reduced work performance and higher risk of accident. Following modern fatigue risk management systems (FRMS), acceptable performance could be maintained by the mobilization of appropriate mitigation strategies. However, the effective deployment of such strategies assume that workers are able to assess their own level of fatigue-related impairments. In this study, we sought to determine whether emergency physicians' subjective feelings of sleepiness could provide accurate knowledge of actual fatigue-related impairments while working extended shifts. We conducted a prospective observational study with a within-subjects repeated measures component. We collected sleep logs, sleepiness ratings and reaction times on a Psychomotor Vigilance Task (PVT) at different time points during shifts. Our results show that the PVT is sensitive to sleep loss and fatigue, with a 10% increase in mean reaction time across the shift. Subjective sleepiness, however, showed no significant association with time since awakening and was not a significant predictor of PVT performance. Our results are consistent with experimental studies showing that individuals tend to underestimate fatigue-related impairments when sleep deprived or functioning under adverse circadian phase. The discrepancy between subjective sleepiness and actual fatigue-related impairments may give workers the illusion of being in control and hinder the deployment of mitigation strategies. Further research is needed to determine the relative weight of circadian phase shifting and cumulative sleep deprivation in the decline of self-knowledge in extended shifts.

- **Keywords:** Extended shift; Sleepiness; Sustained attention; Emergency physician; Self-knowledge

Alain Chavallaz, Adrian Schwaninger, Stefan Michel, Juergen Sauer. [*Some cues are more equal than others: Cue plausibility for false alarms in baggage screening.*](#) **102916.**

This study investigated the effects of cue plausibility in a baggage screening task. 120 participants had to indicate whether a prohibited item was present in a series of grey-scaled X-ray images of baggage. They were assisted by a support system, which pointed at the location of a suspicious object. A 2 × 2 × 2 between-subjects design was used. Cue plausibility for false alarms (i.e. how the cued object was similar to a prohibited item) and support system reliability were manipulated at two levels (high/low). Furthermore, half of participants were provided with a rationale about automation failures (RAF) to reduce their negative impact on trust and performance. The results showed lower performance and more compliance with automation suggestions when cues were implausible than plausible. The RAF increased the response time and did not improve detection performance. Overall, this suggests that effective (computer-based) training is needed to reduce the negative effect of plausible cues.

- **Keywords:** Automation ability; Screening performance; Trust

Mary Lavelle, Gabriel B. Reedy, Sean Cross, Peter Jaye, Thomas Simpson, Janet E. Anderson. [*An evidence based framework for the Temporal Observational Analysis of Teamwork in healthcare settings.*](#) **102915.**

Objective: Effective teamwork is critical to patient safety across multiple healthcare settings. However, current observational tools assessing teamwork performance tend to

be developed for specific settings or tasks and do not capture temporal features of interaction. This study aimed to develop a valid and reliable observational teamwork behaviour framework, which is based on healthcare practice, applicable across a variety of healthcare contexts and can be used to capture temporal team dynamics. **Methods:** Team interactions were audio-visually recorded during routine simulation training at two large clinical education centres specialising in physical and mental healthcare. The framework was based on theoretical models of teamwork and was developed in three steps: 1-micro analysis of verbal and nonverbal behaviour during recorded scenarios (n=20); 2-iterative test and refine cycles; 3-final behavioural framework applied to a cohort of acute emergency scenarios (n=9) by two raters to assess inter-rater agreement. **Results:** The framework contains twenty-three specific verbal and nonverbal behaviours that can be identified during observations. Behaviours are grouped conceptually based on their function resulting in thirteen behavioural functions, which cluster into five overarching teamwork domains. Inter-rater agreement was excellent (Cohen's Kappa = .84, SE = 0.03). **Conclusion:** We present a valid and reliable behavioural framework, grounded in teamwork theory and empirical observations of clinical team behaviour. This framework enables analysis of the nuances and temporal features of clinical practice in depth and across a wide range of clinical contexts and settings. Use of this framework will advance our understanding of teamworking in healthcare.

- **Keywords:** Teamwork; Communication; Observational analysis; Human factors; Patient safety

Anna F. Jolliff, Peter Hoonakker, Kevin Ponto, Ross Tredinnick, Gail Casper, Thomas Martell, Nicole E. Werner. [The desktop, or the top of the desk? The relative usefulness of household features for personal health information management](#). 102912.

Sixty percent of the US population manages at least one chronic illness. For these patients, personal health information management (PHIM) is an integral part of daily life, and largely occurs within the home. However, the way in which the home supports PHIM has not been systematically investigated. The present study examined how members of the diabetic population use features of the home environment to support PHIM. Participants (N=60) explored a simulated home environment, the VR CAVE, and identified the most useful features for performing three examples of PHIM tasks. The computer was perceived as the most useful feature for PHIM. However, perceived usefulness of features varied based on the PHIM task performed and the rooms in which features appeared. We conclude that a detailed study of the affordances of features is necessary to ease the burden of managing chronic illness, particularly diabetes mellitus, in the sociotechnical system of the home.

- **Keywords:** Personal health information management; Sociotechnical systems; Chronic illness; Virtual reality

Rebecca Mitchell, Mona Faris, Reidar Lystad, Diana Fajardo Pulido, Grace Norton, Melissa Baysari, Robyn Clay-Williams, Peter Hibbert, Andrew Carson-Stevens, Cliff Hughes. [Using the WHO International Classification of patient safety framework to identify incident characteristics and contributing factors for medical or surgical complication deaths](#). 102920.

This study aimed to operationalise and use the World Health Organisation's International Classification for Patient Safety (ICPS) to identify incident characteristics and contributing factors of deaths involving complications of medical or surgical care in Australia. A sample of 500 coronial findings related to patient deaths following complications of surgical or medical care in Australia were reviewed using a modified-ICPS (mICPS). Over

two-thirds (69.0%) of incidents occurred during treatment and 27.4% occurred in the operating theatre. Clinical process and procedures (55.9%), medication/IV fluids (11.2%) and healthcare-associated infection/complications (10.4%) were the most common incident types. Coroners made recommendations in 44.0% of deaths and organisations undertook preventive actions in 40.0% of deaths. This study demonstrated that the ICPS was able to be modified for practical use as a human factors taxonomy to identify sequences of incident types and contributing factors for patient deaths. Further testing of the mICPS is warranted.

- **Keywords:** Patient safety; Taxonomy; Error

Katherine van Lopik, Maren Schnieder, Richard Sharpe, Murray Sinclair, Chris Hinde, Paul Conway, Andrew West, Martin Maguire. [Comparison of in-sight and handheld navigation devices toward supporting industry 4.0 supply chains: First and last mile deliveries at the human level.](#) 102928.

Last (and First) mile deliveries are an increasingly important and costly component of supply chains especially those that require transport within city centres. With reduction in anticipated manufacturing and delivery timescales, logistics personnel are expected to identify the correct location (accurately) and supply the goods in appropriate condition (safe delivery). Moving towards more environmentally sustainable supply chains, the last/first mile of deliveries may be completed by a cyclist courier which could result in significant reductions in congestion and emissions in cities. In addition, the last metres of an increasing number of deliveries are completed on foot i.e. as a pedestrian. Although research into new technologies to support enhanced navigation capabilities is ongoing, the focus to date has been on technical implementations with limited studies addressing how information is perceived and actioned by a human courier. In the research reported in this paper a comparison study has been conducted with 24 participants evaluating two examples of state-of-the-art navigation aids to support accurate (right time and place) and safe (right condition) navigation. Participants completed 4 navigation tasks, 2 whilst cycling and 2 whilst walking. The navigation devices under investigation were a handheld display presenting a map and instructions and an in-sight monocular display presenting text and arrow instructions. Navigation was conducted in a real-world environment in which eye movements and device interaction were recorded using Tobii-Pro 2 eye tracking glasses. The results indicate that the handheld device provided better support for accurate navigation (right time and place), with longer but less frequent gaze interactions and higher perceived usability. The in-sight display supported improved situation awareness with a greater number of hazards acknowledged. The benefits and drawbacks of each device and use of visual navigation support tools are discussed.

- **Keywords:** Navigation; Eye-tracking; Map; Handheld device; In-sight display; Cycling; Pedestrian; Hazard perception

Marcus Yung, Ahmet Kolus, Richard Wells, W. Patrick Neumann. [Examining the fatigue-quality relationship in manufacturing.](#) 102919.

A recent systematic review identified 73 empirical studies that linked human factors (HF) with manufacturing quality. Human fatigue was noted as a frequent ($n = 26$) issue in the HF-quality relationship – a finding that warrants closer examination. We extend this review by investigating the relationship between fatigue and manufacturing quality by identifying how fatigue has been conceptualized and measured, and we attempted to quantify their relationship. From the original database, 12 of 26 relevant studies (46%) indicated that physical fatigue was the primary contributor to observed quality deficits. There was a positive relationship between fatigue and quality deficits, with fatigue accounting up to 42% of the variance. More studies are needed to improve the resolution, specificity, and power of these analyses. This study sheds light on the role of

HF and human fatigue effects on manufacturing quality with macroergonomic implications for embedding HF aspects into design and quality assurance processes.

- **Keywords:** Systematic review; System performance; Quality assurance; Ergonomics

Sudeep Hegde, Aaron Z. Hettinger, Rollin J. Fairbanks, John Wreathall, Seth A. Krevat, Cullen D. Jackson, Ann M. Bisantz. [Qualitative findings from a pilot stage implementation of a novel organizational learning tool toward operationalizing the Safety-II paradigm in health care.](#) 102913.

„Safety-II“ is a new approach to safety, which emphasizes learning proactively about how safety and efficacy are achieved in everyday frontline work. Previous research developed a new lesson-sharing tool designed based on the Safety-II approach: Resilience Engineering Tool to Improve Patient Safety (RETIPS). The tool comprises questions designed to elicit narratives of adaptations that have contributed to effectiveness in care delivery. The purpose of this study is to revise and validate the design of RETIPS. The tool was revised based on feedback of clinicians at a large multi-specialty hospital, resulting in a version customized for anesthesia residents, RETIPS-AnRes. RETIPS-AnRes was administered on a pilot-basis to anesthesia resident groups for a limited period of time. A review of the reports obtained shows a strong alignment of responses with the conceptual basis of the tool, i.e. learning about how things go well in everyday work. The exemplars include both, specific instances of successful patient care, as well as generic routines that contribute to safe and/or effective care delivery. These findings support RETIPS as a tool to operationalize the Safety-II paradigm in healthcare. Lessons and implications for implementation on a wider scale are discussed.

- **Keywords:** Learning systems; Quality and safety improvement; Resilience; Appreciative inquiry

William Payre, Cyriel Diels. [I want to brake free: The effect of connected vehicle features on driver behaviour, usability and acceptance.](#) 102932.

This study evaluated the effectiveness and acceptance of four connected vehicle features, i.e. Emergency Electronic Brake Lights (EEBL), Emergency Vehicle Warning (EVW), Roadworks warning (RWW) and Traffic Condition Warning (TCW) which were presented via a mobile phone mounted near the line of sight. A driving simulator study was conducted in which 36 drivers were exposed to different levels of urgent and critical situations. They involved the approach of an emergency vehicle, an emergency braking of a lead vehicle, a roadworks area and a congested section of a road. All these events took place in a simulated motorway scenario. In the EEBL event, the vehicle braking ahead with the brake lights on was either visible or not (between-subjects). Whereas no effect of RWW and TCW were observed on driving behaviour, results showed that drivers who were shown the EEBL warnings had shorter braking and decelerating response times, and a slower mean speed during the events, and this was independent of brake lights visibility. The EVW resulted in participants giving way to the emergency vehicle (i.e. staying on the slow lane instead of overtaking slower vehicles) more frequently than those who did not receive the warning. The mobile phone app was accepted and considered usable. Locating the mobile phone in different locations within the drivers' line of sight (i.e. dashboard, instrument cluster) did not impact significantly neither drivers' attitudes nor behaviour. Additional in-vehicle information systems could enhance safety and allow emergency vehicles to get faster to their destination.

- **Keywords:** Connected vehicle; Human machine interface; Mobile phone app; Road safety; Behaviour; Usability; Acceptance; Driving; Emergency electronic brake lights; Emergency vehicle warning; V2V; V2I

Germán Gálvez-García, Nerea Aldunate, Claudio Bascour-Sandoval, Mauricio Barramuño, Fernando Fonseca, Emilio Gómez-Milán. [Decreasing motion sickness by mixing different techniques.](#) 102931.

We investigated the effectiveness of galvanic cutaneous stimulation (GCS) and auditory stimulation (AS) together and separately in mitigating motion sickness (MS). Forty-eight drivers (twenty-two men; mean age = 21.58 years) participated in a driving simulation experiment. We compared the total scores of the Simulator Sickness Questionnaire (SSQ) across four different stimulation conditions (GCS, AS, Mixed GCS-AS and no stimulation as a baseline condition). We provided evidence that mixing techniques mitigates MS owing to an improvement in body balance; furthermore, mixing techniques improves driving behavior more effectively than GCS and AS in isolation. We encourage the use of the two techniques together to decrease MS.

- **Keywords:** Motion sickness; Galvanic cutaneous stimulation; Mixing techniques

Sarah Carter, Emma Field, Elspeth Oppermann, Matt Brearley. [The impact of perceived heat stress symptoms on work-related tasks and social factors: A cross-sectional survey of Australia's Monsoonal North.](#) 102918.

Heat poses a significant occupational hazard for labour-intensive workers in hot and humid environments. Therefore, this study measured the prevalence of heat-stress symptoms and impact of heat exposure on labour-intensive industries within the Monsoonal North region of Australia. A cohort of 179 workers completed a questionnaire evaluating environmental exposure, chronic (recurring) and/or severe (synonymous with heat stroke) symptoms of heat stress, and impact within work and home settings. Workers reported both chronic (79%) and severe (47%) heat stress symptoms, with increased likelihood of chronic symptoms when exposed to heat sources (OR 1.5–1.8, $p = 0.002$ – 0.023) and decreased likelihood of both chronic and severe symptoms when exposed to air-conditioning (Chronic: OR 0.5, $p = <0.001$, Severe: OR 0.7, $p = 0.019$). Negative impacts of heat exposure were reported for both work and home environments (30–60% respectively), highlighting the need for mitigation strategies to reduce occupational heat stress in the Monsoonal North.

- **Keywords:** Heat related illness; Northern Australia; Thermoregulation; Workplace health and safety

Rachel L. Morrison, Roy K. Smollan. [Open plan office space? If you're going to do it, do it right: A fourteen-month longitudinal case study.](#) 102933.

There are compelling findings that open-plan office environments are associated with declines in employee wellbeing. In spite of this, the move towards shared office environments continues; yet there is a lack of research describing open-plan offices that have positive outcomes for workers. We describe a "best practice" open-plan fit-out of a law firm and provide data from occupants relating to their performance, well-being, and collegial relationships. Six months after moving to an open-plan office, staff were anonymously surveyed, and 24 were interviewed. Fourteen months later, occupants responded to a follow-up survey. Positive outcomes relating to aesthetics, collegiality, and communication were achieved through good technical design and thoughtful ergonomic assessment of the needs of employees and the requirements of their tasks. A gender difference emerged whereby female, but not male, workers in this environment reported feeling observed. This has implications for the relatively different impact these environments may have on workers. Thus, by following ergonomic principles to create

open-plan offices that are 'safe by design' organizations can ameliorate many of the negative consequences associated with these environments.

- **Keywords:** Open-plan offices; Well-being; Gender; Productivity

Alessandro Jatobá, Hugo Cesar Bellas, Bárbara Bulhões, Isabella Koster, Rodrigo Arcuri, Paulo Victor R. de Carvalho. [Assessing community health workers' conditions for delivering care to patients in low-income communities.](#) 102944.

In this paper we study the working conditions of Community Health Workers in performing house calls within low-income, violent communities in order to understand the challenges in delivering primary care in developing countries. We conducted field studies in two primary healthcare clinics and telephone surveys for 5 months in 2017 within systematic sample of 1690 community health workers based on clinics distributed along the health regions of the city of Rio de Janeiro, Brazil. A number of 759 interviews were completed, approximately 50% of the sample, 86% men and 14% women. Most participants are 30–39 years old (35%), followed by 27% of 40–49 years old participants. Results show that exposure to territorial violence and environmental or health-related diseases significantly affects CHWs. Moreover, CHWs have to develop a significant set of skills to cope with aspects of the territory, and those skills are not present in their training. As community health workers work on the sharp end of the healthcare system, responsible for outreaching, community education, counseling, and social support, our study presents contributions to government and management levels on working conditions inside communities, constraints in assistance, and difficulties in implementing primary care policies.

- **Keywords:** Community health workers; Family health; Primary health care

Kin Cheung, Jay Dai, Chun Lok Cheung, Hung Kai Cho, Yan Lam Chow, Ka Yin Fung, Wai Sze Lam, Hoi Leong Calvin Li, Sin Ying Ng, Man Ying Ngan, Grace Szeto. [The biomechanical evaluation of patient transfer tasks by female nursing students: With and without a transfer belt.](#) 102940.

This study was to examine the kinematics, muscle activities, and perceived physical exertion in different regions of the spine during patient transfers by nursing students between a bed and a wheelchair, with or without a transfer belt in a laboratory setting. Results showed that with the effect of the belt, the % maximum voluntary contraction of the lumbar erector spinae was reduced significantly by nearly 10%. Muscle activity was significantly increased in thoracic erector and multifidus spinae during wheelchair-to-bed transfer, compared to bed-to-wheelchair transfers. There was no significant effect of belt or task on the spinal angular displacement in different spinal regions. Using the transfer belt was associated with a significantly decreased score for perceived exertion. In conclusion, this study supports the use of a transfer belt contributing to lower muscle activity and lower perceived physical exertion in the low back.

- **Keywords:** Low-tech patient transfer assistive devices; Electromyography; Kinematics

Grégoire S. Larue, Ross A. Blackman, James Freeman. [Frustration at congested railway level crossings: How long before extended closures result in risky behaviours?](#) 102943.

Drivers' non-compliance with rules is a prominent factor in collisions with trains at railway level crossings. Road user impatience and frustration has been identified as an underlying factor in non-compliance and can be characterised as a specific risk factor.

However, research on non-compliance related to waiting times and driver inconvenience lacks in the literature. This paper, therefore, seeks to enhance the currently limited understanding of the relationship between waiting times and risky driver behaviour. An Advanced Driving Simulator was used to obtain objective measures of level crossing non-compliance. Subjective measures on driver frustration and decision-making processes were also collected. Sixty participants completed six driving tasks each, with the tasks varying in terms of traffic conditions, number of trains and associated waiting times. This study shows that increased waiting times result in higher levels of frustration and an increased likelihood of risky driving behaviour, particularly for waiting times longer than 3 min. Non-compliance included entering the activated crossing before boom gates are down, entering the crossing after the train passage but before signals are deactivated, stopping/reversing on the crossing. Subjective data revealed that participants did not comply with level crossing rules due to factors including time pressure, impatience/frustration and low perceived risk. The results suggest that, where possible, waiting times should be standardised at values lower than 3 min to reduce the likelihood of risky road user behaviour.

- **Keywords:** Road safety; Rail safety; Railway level crossing; Congestion; Risky behaviour; Frustration

Naoshi Kakitsuba. [Comfortable indoor lighting conditions for LEDlights evaluated from psychological and physiological responses.](#) 102941.

Comfortable light emitting diode (LED) lighting conditions were examined for psychological and physiological responses. Eight male and eight female subjects participated in a series of experiments. They were exposed to light emitted from LED lights of 3000 K in the ranges of 150–400 lux and 1500–5000 lux; 4000 K in the ranges of 140–640 lux and 2000–5000 lux; and 5000 K in the ranges of 70–270 lux and 2500–7000 lux. Illuminance at a given correlated color temperature was first maintained at the lowest value in the designated range and then increased in a stepwise manner. On reaching the highest value in the range, it was then decreased to the lowest value in a stepwise manner. The subjects were required to indicate their perception of brightness, glare, and comfort at the controlled illuminance levels. Electrocardiogram and electroencephalogram data were monitored continuously throughout exposure. The results showed that the boundary illuminances estimated from psychological and physiological responses did not significantly differ between male and female subjects, but differed markedly from those of fluorescent lights tested in a previous study. The high boundaries of the LED lights were higher than those of the fluorescent lights. The low boundaries of the LED lights at 3000 K and 4000 K were higher than those of the fluorescent lights, but the boundaries at 5000 K were lower than those of the fluorescent lights. These differences may be due to differences in the spectral distribution and luminance for a given illuminance between LED and fluorescent lights.

- **Keywords:** Light intensity; Correlated color temperature; Heart rate variability; Electroencephalogram

Katya Kovac, Grace E. Vincent, Sarah M. Jay, Madeline Sprajcer, Brad Aisbett, Leon Lack, Sally A. Ferguson. [The impact of anticipating a stressful task on sleep inertia when on-call.](#) 102942.

Sleep inertia, the state of reduced alertness upon waking, can negatively impact on-call workers. Anticipation of a stressful task on sleep inertia, while on-call was investigated. Young, healthy males ($n = 23$) spent an adaptation, control and two counterbalanced on-call nights in the laboratory. When on-call, participants were told they would be woken to a high or low stress task. Participants were not woken during the night, instead were given a 2300–0700 sleep opportunity. Participants slept ~7.5-h in all conditions. Upon waking, sleep inertia was quantified using the Karolinska Sleepiness Scale and

Psychomotor Vigilance and Spatial Configuration Tasks, administered at 15-min intervals. Compared to control, participants felt sleepier post waking when on-call and sleepest in the low stress compared to the high stress condition ($p < .001$). Spatial performance was faster when on-call compared to control ($p < .001$). Findings suggest that anticipating a high-stress task when on-call, does not impact sleep inertia severity.

- **Keywords:** Stress; Cognitive performance; Stand-by work

A. Muller, C. Pontonnier, X. Robert-Lachaine, G. Dumont, A. Plamondon. [Motion-based prediction of external forces and moments and back loading during manual material handling tasks](#). 102935.

This paper evaluates a method for motion-based prediction of external forces and moments on manual material handling (MMH) tasks. From a set of hypothesized contact points between the subject and the environment (ground and load), external forces were calculated as the minimal forces at each contact point while ensuring the dynamics equilibrium. Ground reaction forces and moments (GRF&M) and load contact forces and moments (LCF&M) were computed from motion data alone. With an inverse dynamics method, the predicted data were then used to compute kinetic variables such as back loading. On a cohort of 65 subjects performing MMH tasks, the mean correlation coefficients between predicted and experimentally measured GRF for the vertical, antero-posterior and medio-lateral components were 0.91 (0.08), 0.95 (0.03) and 0.94 (0.08), respectively. The associated RMSE were 0.51 N/kg, 0.22 N/kg and 0.19 N/kg. The correlation coefficient between L5/S1 joint moments computed from predicted and measured data was 0.95 with a RMSE of 14 Nm for the flexion/extension component. In conclusion, this method allows the assessment of MMH tasks without force platforms, which increases the ecological aspect of the tasks studied and enables performance of dynamic analyses in real settings outside the laboratory.

- **Keywords:** Ground reaction forces and moments; Lifting; Kinematics; Inverse dynamics; L5/S1 joint moment

Magdalena Anna Jaworek, Tadeusz Marek, Waldemar Karwowski. [The scale of Work-Related Affective Feelings \(WORAF\)](#). 102945.

Interest in the field of emotions in the workplace continues to grow. However, a narrow range of measurements exists for the examination of affective states in organizational settings, all of which were developed based on the discrete-emotions approach. The main objective of the current study was to develop and validate a new instrument to assess four work-related (WR) affective feelings (WORAF): WR feelings of happiness, WR feelings of anxiety, WR feelings of anger, and WR feelings of dejection. Three independent samples of Polish employees in different occupations were included in the study ($n = 297$, $n = 3019$, $n = 284$). The results provide significant evidence for the validity of the proposed WORAF scale, although further investigations are needed.

- **Keywords:** Work-related affective feelings; Discrete-emotions approach; Scale development; Validation

Ruijun Liu, Chu Zhuang, Rui Yang, Liang Ma. [Effect of economically friendly acustimulation approach against cybersickness in video-watching tasks using consumer virtual reality devices](#). 102946.

Background: Consumer virtual reality (VR) devices are becoming more prevalent in the market, but cybersickness induced by VR devices limits their potential application and promotion. Acustimulation has been found effective in reducing cybersickness symptoms. However, in previous forms, the more effective way of acustimulation is either intrusive

or electrical which is hard to be applied to daily VR use. **Purpose:** In this study, we aimed to find a both simple and more effective acustimulation approach, acupressure plus acupaste (AcP+) to reducing the adverse effects caused by cybersickness from VR applications. **Method:** In this study, we set three conditions: acupressure plus acupaste (AcP+) (main condition of interest), acupressure with fake acupaste (AcP), and a no acustimulation condition (NoAcP). In AcP and AcP + conditions, we applied acupressure or acupressure with true acupaste on P6 point before conducting video-watching tasks using VR headsets, while in NoAcP condition, participants received no special treatment before video-watching tasks. We used questionnaires to measure symptoms of cybersickness and compared the results between these 3 conditions, especially between acupressure plus acupaste (AcP+) and acupressure (AcP) to examine the effect of AcP+, and compared AcP and AcP+ with NoAcP to confirm the effect of acustimulation. **Result:** Participants reported significant fewer symptoms of cybersickness nausea feelings in both acustimulation methods, compared with NoAcP; and AcP+ was more effective than AcP against cybersickness on visual oculomotor aspect, and facilitated cybersickness recovery. **Implication:** It would be promising to develop acupressure equipment and apply stimulation before VR application to reduce cybersickness.

- **Keywords:** VR headset; Cybersickness; Acustimulation

Els Clays, David Hallman, Jodi Oakman, Andreas Holtermann. [Objectively measured occupational physical activity in blue-collar workers: What is the role of job type, gender and psychosocial resources?](#) 102948.

The aim was to describe occupational physical activity (OPA) and examine the role of psychosocial job resources among blue-collar workers. In a sample of 198 workers (57% male; mean age 44.9 (SD 9.9) year) from 7 companies in Denmark, two accelerometers (Actigraph) were placed on the thigh and trunk during 1–5 consecutive days, to determine working time spent standing, walking, on feet and in activity of moderate to vigorous intensity level (MVPA). The level of influence and social support at work were assessed by questionnaire. The exposure to OPA significantly varied by particular job type, especially in male predominant occupations. Overall, psychosocial job resources did not affect the exposure to OPA. These findings suggest that workplace interventions aiming to prevent adverse outcomes of OPA among blue-collar workers ought to focus on task redesign and target work organizational factors related to specific job type.

- **Keywords:** Occupational physical activity; Psychosocial; Blue-collar; Work organization; Objective measurement

Alexander Robert Kett, Freddy Sichting. [Sedentary behaviour at work increases muscle stiffness of the back: Why roller massage has potential as an active break intervention.](#) 102947.

There is increasing evidence that subjects who are exposed to long sitting periods suffer from musculoskeletal discomfort and back pain. The underlying mechanism and effective prevention strategies are still largely unknown. In this study, muscle stiffness of the back was measured in 59 office workers who followed their usual desk work regime for 4.5 h in a sitting posture. The sitting period was either followed by an 8-min roller massage intervention or a controlled standing task. Results showed that muscle stiffness increased significantly after the 4.5 h sitting period. When the sitting period was followed by roller massage, the stiffness values dropped slightly below baseline stiffness. In contrast, the stiffness values remained increased when the sitting period was followed by controlled standing. This study indicates that short-duration tissue manipulation can be an effective active break between prolonged sitting periods to prevent musculoskeletal issues, such as musculoskeletal discomfort and back pain.

- **Keywords:** Prolonged sitting; Muscle stiffness; Workplace intervention; Roller massage; Back muscles; Sedentary work

Katie A. Weatherson, Kelly B. Wunderlich, Guy E. Faulkner. [Impact of a low-cost standing desk on reducing workplace sitting \(StandUP UBC\): A randomised controlled trial.](#) 102951.

Sit-stand desks can reduce occupational sitting time, however, their cost can limit scalability. The purpose of this study was to evaluate the impact of a low-cost standing desk on objectively-measured occupational sitting and prolonged sitting bouts over 3- and 6-months. Secondary outcomes included self-report work engagement and occupational fatigue. Forty-eight office employees (91.7% female, Mage = 39.8 ± 10.1) were randomized to receive a low-cost standing desk or to a control group. At 3-months, the intervention group sat 0.7 h (42min) less at work compared to the control group; F(1, 45) = 5.90, partial η^2 = 0.12, p = .019. The effect was small, yet comparable to findings from studies using costlier alternatives. However, these reductions were not maintained at 6-months. No changes in prolonged sitting bouts or secondary outcomes were found. There is some potential for low-cost standing desk converters as a scalable workplace health intervention. **Trial registration:** ClinicalTrials.gov, NCT03375749, Registered 18 December 2017, <https://clinicaltrials.gov/ct2/show/NCT03375749?term=NCT03375749&rank=1>.

- **Keywords:** Sedentary behaviour; Sitting; Standing desk; Work; Adults

Julie Renberg, Maren Trones Christiansen, Øystein Nordrum Wiggen, Karin Roeleveld, Ellen Marie Bardal, Randi Eidsmo Reinertsen. [Metabolic rate and muscle activation level when wearing state-of-the-art cold-weather protective clothing during level and inclined walking.](#) 102956.

Use of cold-weather personal protective clothing (PPC) in cold climates is essential but can add metabolic cost to the wearer. This study measured the effect of wearing state-of-the-art PPC and personal protective equipment (PPE), with the possible effect of clothing layers and fit, on physiological responses including metabolic rate (MR) and muscle activation level. 19 male participants (80.2 ± 5.9 kg, 181.5 ± 5.1 cm) wore five different clothing ensembles during level (0°) and inclined (6°) walking. Compared to a base layer ensemble (388.7 ± 42.7 W/737.8 ± 57.9 W), wearing a 3-layer PPC ensemble (421.5 ± 44.7 W/811.7 ± 69.2 W) significantly increased MR, and adding PPE (458.3 ± 59.8 W/864.5 ± 71.2 W) further increased MR during level/inclined walking. Independent of the extra weight, adding a middle layer between base layer and outer clothing significantly increased MR during inclined walking only, and no effect of oversized outer clothing was measured.

- **Keywords:** Personal protective equipment; Gross efficiency; Electromyography

Soo-Jeong Lee, David Rempel. [Comparison of lift use, perceptions, and musculoskeletal symptoms between ceiling lifts and floor-based lifts in patient handling.](#) 102954.

Lifting equipment can reduce the risk of injury from patient handling, but limited availability and adoption have been a persistent problem. Data from statewide surveys of California nurses (N = 389) in 2013 and 2016 were analyzed to evaluate lift use, perceptions about lifts and injury risk, and musculoskeletal symptoms by type of available lifts. Nurses with ceiling lifts (23%) were significantly more likely to use lifts and had more positive perceptions about lifts, regarding worker safety, patient safety and comfort, ease of use, access, and storing, than nurses with only floor lifts (77%). Nurses with ceiling lifts reported less low back pain and shoulder pain. Our study findings

suggest that providing ceiling lifts can result in superior outcomes to floor-based lifts in multiple aspects, including better acceptance and use by nurses for patient handling, as well as being associated with reduced work-related musculoskeletal symptoms in the low back and shoulders.

- **Keywords:** Ceiling lift; Musculoskeletal symptoms; Patient lifting equipment

Saryani Asmayawati, Jim Nixon. [Modelling and supporting flight crew decision-making during aircraft engine malfunctions: developing design recommendations from cognitive work analysis](#). 102953.

In this article, we analyse flight crew response to an in-flight powerplant system malfunction (PSM) using control task analysis. We demonstrate the application of the decision ladder template and the skills, rules, and knowledge (SRK) framework to this new area of inquiry. Despite the high reliability of turbofan engines, accidents and incidents involving PSM still occur. During these unusual events, flight crew have not always responded appropriately, leading to a reduction in safety margins or disruption of operations. This article proposes recommendations for technological and information system that can support flight crew in responding safely and appropriately to a PSM. These recommendations focus on new ways in which information from engine health monitoring system and other sources of data can be utilised and displayed. Firstly, we conducted knowledge elicitation using Critical Decision Method (CDM) interviews with airline pilots who have experienced real or simulated PSM events. We then developed generic decision ladders using the interview data, operations manual, training manual, and other guideline documents. The generic decision ladders characterise the different stages of responding to PSM identified as part of the research. These stages include: regaining and maintaining control of aircraft, identifying PSM and selecting appropriate checklists to secure the engine, and modifying the flight plan. Using the decision ladders and insights from the CDM interviews, we were able to identify cognitive processes and states that are more prone to errors and therefore more likely to generate an inappropriate response. Using the SRK framework, we propose design recommendations for technological and information systems to minimise the likelihood of such inappropriate response. We conclude that this combination of methods provides a structured and reliable approach to identifying system improvements in complex and dynamic work situations. Our specific contributions are the application of these techniques in the unrepresented area of flight operations, and the development of evidence-based design recommendations to improve flight crew response to in-flight powerplant system malfunctions.

- **Keywords:** Cognitive work analysis; Flight crew decision-making; Aircraft engine malfunction

Volkan Sevinc, Mehmet Ilker Berkman. [Psychometric evaluation of Simulator Sickness Questionnaire and its variants as a measure of cybersickness in consumer virtual environments](#). 102958.

Cybersickness, i.e. visually induced motion sickness, remains as a negative effect that is detrimental to the user experience of VEs (virtual environments) developed for VR (virtual reality) consumers. As the VR technology evolves, it is rather triggered by application aspects rather than hardware limitations. For this reason, there is still a need for a measurement method to assess and compare VEs for cybersickness effects. SSQ (Simulation Sickness Questionnaire) is used for measuring users' level of sickness symptoms and is highly appreciated in VR research. However, it is criticized for its psychometric qualities and applicability in VR, as a measure of cybersickness. Recently, two variants of SSQ were offered for measuring cybersickness, CSQ (Cybersickness Questionnaire) and VRSQ (Virtual Reality Sickness Questionnaire). There is also another variant with a different factor structure, which we call FSSQ, that is based on French

translation of SSQ. Our study compares SSQ and these variants for their psychometric qualities; construct validity, discriminant validity, internal reliability, test-retest reliability and sensitivity to distinguish application aspects of VEs that are related to cybersickness. Using a within-subjects experiment design, we evaluated 7 different VEs with 32 participants through 9 sessions, resulting with 288 responses to the 16-item SSQ. Results suggested that both VRSQ and CSQ were valid and reliable measures of cybersickness, as well as being sensitive to application aspects such as translational and rotational movements required by users for navigation in VEs. Compared to SSQ and FSSQ; the cybersickness questionnaires, CSQ and VRSQ, revealed better indicators of validity. On the other hand, we assume that the development of the two cybersickness scales had limitations in sample size to represent VR consumers and limitations in stimuli to represent the applications aspects of consumer VEs. We suggest further evaluation of cybersickness symptoms with larger samples and broader range of applications to identify the symptoms and the construct of a subjective measurement tool.

- **Keywords:** Cybersickness; Virtual reality; Visually induced motion sickness; Simulator sickness questionnaire; Scale; Psychometric evaluation

Arian Iraqi, Natasa S. Vidic, Mark S. Redfern, Kurt E. Beschorner.
[Prediction of coefficient of friction based on footwear outsole features.](#)
102963.

Traction testing of footwear is expensive, which may create barriers for certain users to assess footwear. This study aimed to develop a statistical model that predicts available coefficient of friction (ACOF) under boundary lubrication conditions based on inexpensive measurements of footwear outsole features. Geometric and material hardness parameters were measured from fifty-eight footwear designs labeled as slip-resistant. A robotic friction measurement device was used to quantify ACOF with canola oil as the contaminant. Stepwise regression methods were used to develop models based on the outsole parameters and floor type to predict ACOF. The predictive ability of the regression models was tested using the k-fold cross-validation method. Results indicated that 87% of ACOF variation was explained by three shoe outsole parameters (tread surface area, heel shape, hardness) and floor type. This approach may provide an assessment tool for safety practitioners to assess footwear traction and improve workers' safety.

- **Keywords:** Slips; Coefficient of friction; Shoe safety; Shoe traction assessment; Slip-resistant

Lena Norrbrand, Roger Kölegård, Michail E. Keramidas, Igor B. Mekjavic, Ola Eiken.
[Finger- and toe-temperature responses to local cooling and rewarming have limited predictive value identifying susceptibility to local cold injury-a cohort study in military cadets.](#)
102964.

The purpose was to evaluate whether a cold-water immersion test could be used to identify individuals susceptible to local cold injuries (LCI). Sixty-five healthy non-injured (N-I) subjects, and fifteen subjects, who were tested either prior to or after a LCI, sequentially immersed one hand and one foot, in 8 °C water for 30 min (CWI phase); this was followed by 15 min of spontaneous rewarming (RW phase). The LCI group showed a lower toe temperature during the CWI phase, and a lower maximum RW temperature of the fingers than the N-I group. However, digit temperatures during the CWI and RW phases exhibited low predictive values for LCI, e.g. results implied that to identify 80% of the LCI subjects, 34–78% of the N-I subjects would also be excluded. Thus, the results suggest that, in practice, hand or foot cold-water immersion tests cannot be used to identify individuals at high risk of LCI.

- **Keywords:** CIVD; Water immersion; Frostbite

Carmen Bruder, Catrin Hasse. [What the eyes reveal: Investigating the detection of automation failures](#). 102967.

In order to detect automation failures in a timely manner, operators are required to monitor automated systems efficiently. The present study analysed eye movements to predict whether or not participants could detect an automation failure. Eye movements were recorded whilst 101 participants were monitoring an automated system where automation failures occurred at irregular intervals. A main result is that about 75.6 per cent of automation failure detections were predicted successfully by the corresponding eye movements. In cases where failures were detected successfully, relevant information is monitored more often and more intensively, in particular shortly before an automation failure happens and while it is happening. The findings are discussed in the context of the personnel selection and training of aviation operatives, as well as incident reporting as used in air traffic control (ATC).

- **Keywords:** Human monitoring; Automation failures; Failure detection; Personnel selection; Eye tracking; Eye movements

Stefanie Klatt, Nicholas J. Smeeton. [Immersive screens change attention width but not perception or decision-making performance in natural and basic tasks](#). 102961.

In the last decades, a number of studies have examined people's perceptual and attentional capabilities using flat screen displays. The completion of studies using curved displays/screens has been neglected so far, despite their advantage of creating a more immersive and life-like experience. In two studies, we analysed possible performance differences between subjects' perceptual and attentional capabilities during a decision-making task whilst viewing life-size stimuli on large flat and curved immersive screens. In Study 1, participants performed an attention-demanding shape discrimination task. In Study 2, participants performed a more naturalistic football-specific discrimination task. Results of both studies revealed no differences in perception and decision making between screen conditions, but that attention can be directed across greater visual angles on immersive screens compared to flat screens. The findings suggest that attention can be directed across a larger visual angle on curved screens compared to flat screens probably because curved screens distort the image less than flat screens. This study has implications for the use of flat screens in studies that examine perceptual and attentional capabilities in the visual periphery.

- **Keywords:** Attentional distortions; Focus of attention; Football discrimination task

Arun Ulahannan, Rebecca Cain, Simon Thompson, Lee Skrypchuk, Alex Mouzakitis, Paul Jennings, Stewart Birrell. [User expectations of partial driving automation capabilities and their effect on information design preferences in the vehicle](#). 102969.

Partially automated vehicles present interface design challenges in ensuring the driver remains alert should the vehicle need to hand back control at short notice, but without exposing the driver to cognitive overload. To date, little is known about driver expectations of partial driving automation and whether this affects the information they require inside the vehicle. Twenty-five participants were presented with five partially automated driving events in a driving simulator. After each event, a semi-structured interview was conducted. The interview data was coded and analysed using grounded theory. From the results, two groupings of driver expectations were identified: High Information Preference (HIP) and Low Information Preference (LIP) drivers; between these two groups the information preferences differed. LIP drivers did not want detailed

information about the vehicle presented to them, but the definition of partial automation means that this kind of information is required for safe use. Hence, the results suggest careful thought as to how information is presented to them is required in order for LIP drivers to safely using partial driving automation. Conversely, HIP drivers wanted detailed information about the system's status and driving and were found to be more willing to work with the partial automation and its current limitations. It was evident that the drivers' expectations of the partial automation capability differed, and this affected their information preferences. Hence this study suggests that HMI designers must account for these differing expectations and preferences to create a safe, usable system that works for everyone.

- **Keywords:** Driving simulator; Qualitative; Autonomous vehicle; SAE level 2; Partial automation; Information preferences; HMI

Andrea F. Wilkinson, Alexs A. Matias, Cassandra I.K. Eddy, Edgard MKVK. Soares, Jeffery L. King, Denise L. Smith. [Physiologic strain of SCBA confidence course training compared to circuit training and live-fire training.](#) 102966.

Firefighting is a dangerous occupation and even training carries substantial risks. Self-contained breathing apparatus confidence courses (SCBACC) are a common type of training. **Purpose:** Compare the physiological strain of SCBACC to live-fire training (LFT) and circuit training (CT) among academy cadets. **Methods:** Cadets wore physiologic status monitors to assess heart rate (HR) and estimated core temperature (ECT) during CT, LFT, and SCBACC of similar duration (33–38 min). **Results:** Data from 52 cadet firefighters (28 ± 4 yrs old) were analyzed. ECT (38.6 ± 0.4 vs 39.3 ± 0.7 vs $39.3 \pm 0.6^\circ\text{C}$), peak HR (182.6 ± 9.1 vs 192.7 ± 9.5 vs 195.9 ± 9.6 bpm), and age-predicted maximal HR (APMHR%; 94.6 ± 4.6 vs 99.9 ± 4.9 vs $101.5 \pm 4.8\%$) were significantly ($p < 0.05$) lower for CT than SCBACC and LFT, respectively. **Conclusions:** SCBACC produced physiological strain greater than CT and similar to LFT. SCBACC resulted in sustained HR at 100% of age-predicted maximal values, a peak ECT of 39.3°C , and should be considered as physiologically stressful as LFT.

- **Keywords:** Firefighting; Fire fighter; Estimated core temperature; Heat stress

Sean Hudson, Carlton Cooke, Simeon Davies, Sacha West, Raeeq Gamiieldien, Chris Low, Ray Lloyd. [Inter-individual variability in load carriage economy and comparisons between different load conditions.](#) 102968.

Equivocal findings exist for the economy associated with load carried close to the body's centre of mass. Individual variation could explain some of the equivocal findings. This research aimed to examine the extent of individual variation in loaded walking economy. Eighteen females carried load on the back, head and split between the front and back. Individual variation in relative load carriage economy (ELI) was primarily assessed using standard deviation, coefficients of variation (CV) and intraclass correlation coefficients (ICC). There was large inter-individual variation in ELI values with highest mean CV's of 16%, 12% and 10% for head-, back- and combined front and back-loading. Mean ELI values were not significantly different between methods. The large amount of individual variation found here suggests future load carriage research should account for individual variation, particularly when considering sample size and when making inferences on the economy associated with different types of load carriage using group mean data.

- **Keywords:** Load carriage; Economy; Physiology; Individual variation; Physical work

Eleanor J. Harvey, James A. Pinder, Roger A. Haslam, Andrew R.J. Dainty, Alistair G. Gibb. [The use of actor-based immersive health and safety inductions: Lessons from the Thames Tideway Tunnel megaproject.](#) 102955.

Health and safety inductions are ubiquitous in construction but tend to be poorly designed and suffer low levels of worker engagement. In this paper we report on the evaluation of an innovative, full day, actor-based health and safety induction called EPIC, currently being used on London's Thames Tideway Tunnel megaproject. As of March 2019, more than 14,000 individuals had attended EPIC. This evaluation examines the impact of EPIC from the perspective of participants and other stakeholders, and considers the utility of actor-based immersive health and safety inductions for use more widely, in both construction and other sectors. Using a mixed-method, longitudinal approach to data collection, EPIC is evaluated against Kirkpatrick's (1959) 'four levels' framework of reactions, learning, behaviour change and results. This paper discusses factors which support and hinder actor-based inductions, and the challenges involved in assessing the impact of inductions on subsequent behaviour and health and safety outcomes.

- **Keywords:** Construction; Health and safety; Onboarding; Sociotechnical systems; Training evaluation

Meredith McQuerry. [Effect of structural turnout suit fit on female versus male firefighter range of motion.](#) 102974.

The purpose of this study was to assess the impact of fit on female versus male firefighter range of motion (ROM) when donning a structural turnout ensemble. Three test ensembles were evaluated: base layers (BL), turnout suit (TS), and turnout ensemble (TE). Sixteen career firefighters (10 males; 6 females) completed a user needs survey on fit and mobility restrictions, were measured in a three-dimensional body scanner, performed a static ROM protocol, and recorded ease of movement and comfort perceptions for each ensemble. Average body measurements and absolute ROM values were calculated for each test ensemble and analyzed by gender. Results demonstrated multiple significant differences in body measurements between male and female firefighters when wearing the BL and TS test ensembles. Mobility was significantly reduced when donning the TS and TE, regardless of gender. Significant differences in trunk and shoulder flexion when wearing turnout suits were identified according to participant gender.

- **Keywords:** Mobility; Firefighter; Gender

Natália Kováčsová, Marco Grottoli, Francesco Celiberti, Yves Lemmens, Riender Happee, Marjan P. Hagenzieker, Joost C.F. de Winter. [Emergency braking at intersections: A motion-based motorcycle simulator study.](#) 102970.

Powered two-wheeler riders are frequently involved in crashes at intersections because an approaching car driver fails to give right of way. This simulator study aimed to investigate how riders perform an emergency braking maneuver in response to an oncoming car and, second, whether longitudinal motion cues provided by a motion platform influence riders' braking performance. Twelve riders approached a four-way intersection at the same time as an oncoming car. We manipulated the car's direction of travel, speed profile, and its indicator light. The results showed that the more dangerous the situation (safe, near-miss, impending-crash), the more likely riders were to initiate braking. Although riders braked in the majority of trials when the car crossed their path, they were often unsuccessful in avoiding a collision with the car. No statistically

significant differences were found in riders' initiation of braking and braking style between the motion and no-motion simulator configurations.

- **Keywords:** Perception-action; Rider performance; Hazard; Motorcycle-car interaction; Motorcyclist safety

Tarcisio Abreu Saurin, Riccardo Patriarca. [A taxonomy of interactions in socio-technical systems: A functional perspective](#). 102980.

Although the modelling of interactions has long been at the core of socio-technical systems theory, and is a key for understanding resilience, there is a lack of a holistic taxonomy of interactions. This study introduces a taxonomy of interactions to be used in association with the Functional Resonance Analysis Method (FRAM). The taxonomy has nine criteria: nature of agents, output nature, levelling, waiting time, distance, degree of coupling, visibility, safety and/or security hazards, and parallel replications. For each criterion, two descriptors are proposed: what the interaction looks like; and - when applicable - the variability level of the interaction. The use of the taxonomy is presented for three systems with clearly distinct complexity characteristics: cash withdrawal from an ATM, teaching a university course, and manufacturing operations. These case studies indicate the usefulness of the taxonomy for the identification of leverage points in work system design. They also show the value of modelling the variability of the interactions in FRAM models, in addition to the traditional modelling of the variability of the outputs of functions. Implications of the taxonomy for resilience engineering are discussed.

- **Keywords:** Interactions; Socio-technical systems; Complex systems; FRAM; Human factors; Taxonomy

Sirpa Lusa, Anne Punakallio, Satu Mänttari, Eveliina Korkiakangas, Juha Oksa, Tuula Oksanen, Jaana Laitinen. [Interventions to promote work ability by increasing sedentary workers' physical activity at workplaces – A scoping review](#). 102962.

Although worksite interventions increase physical activity, little is known about their effects on work ability. The objective of this scoping review was to examine the extent, range and nature of interventions to promote work ability by increasing the physical activity or decreasing the sedentary time of sedentary workers in order to identify implications for health promotion at workplaces. We searched Medline, Cochrane Central, and Scopus and identified 29 intervention studies. Using an iterative method, we provided an overview of the study elements and extracted details on study sample, design, intervention content, outcomes, and beneficial effects. Most of the studies (N = 25) were RCTs. Thirteen studies reported beneficial effects on work ability. Tailored and group-based interventions and interventions including environmental actions were often beneficial (9/13). We identified features of feasible and effective interventions for promoting work ability by increasing the physical activity or decreasing the sedentary time of sedentary workers. However, more studies are needed on the sustainability of these effects, and versatile interventions tailored to workers and work demands.

- **Keywords:** Sedentary work; Physical activity; Work ability

Kurt E. Beschorner, Arian Iraqi, Mark S. Redfern, Brian E. Moyer, Rakié Cham. [Influence of averaging time-interval on shoe-floor-contaminant available coefficient of friction measurements](#). 102959.

Available coefficient of friction (ACOF) is a common metric of footwear traction performance. ACOF is the ratio of friction to normal force, often averaged over a time-interval. The time-interval needed to achieve repeatable and valid ACOF is unknown. A

post-hoc analysis was performed on nine shoe-floor-contaminant combinations to assess the repeatability and bias of data averaged across 4 time-intervals (2 ms, 50 ms, 100 ms, 200 ms) after the target normal force was reached. The ability to predict human slips was assessed for ACOF across these intervals. Differences in repeatability and validity across the four intervals were small. However, statistically significant differences were observed for the shortest compared with the longest interval (lower repeatability yet modestly improved predictive ability). Given the limited impact of time-interval on the results, a shorter interval of 50 ms is recommended to enable testing of smaller floor samples.

- **Keywords:** Slips, trips, and falls; Tribometers; Shoe traction

Neil Mansfield, Alessandro Naddeo, Susanne Frohriep, Peter Vink. [*Integrating and applying models of comfort.*](#) **102917.**

This paper gives an overview of the relevance of the comfort concept, its definitions, boundary conditions, and stakeholders. Current comfort theories are presented and reflected on, both in their applicability and testing methodology. Questionnaires commonly used to study comfort and discomfort are also reviewed. An example of a comfort lab is introduced in its functionality and tools, which can be useful as a benchmark for others studying comfort.

- **Keywords:** Product design; Comfort modelling; Discomfort; Comfort

SPECIAL SECTION ON RESILIENCE ENGINEERING

Feng Wang, Jin Tian, Zheyang Lin. [*Empirical study of gap and correlation between philosophies Safety-I and Safety-II: A case of Beijing taxi service system.*](#) **102952.**

In contrast to the conventional safety philosophy (Safety-I) which focuses on 'what goes wrong', a newborn one (Safety-II) focusing on 'what goes right' endows people with more opportunities to realize productive safety in complex socio-technical systems. Yet, it is challenging to make the best of both the philosophies in a period of knowledge transition when they may have to coexist. This work investigates how Safety-II may resemble, differ from, and correlate to Safety-I. From individual, environmental and organizational aspects, 9 impacting factors are identified and expounded comparatively in the two philosophies. To examine impact of the factors on accidents and resilience respectively, an empirical approach is presented in the context of Beijing taxi service system (BTSS). Multiple means such as questionnaire surveys, semi-structured interviews, and statistical analysis with bi-method (Correlation Analysis, and Data Envelopment Analysis) cross-checking are utilized comprehensively to support the empirical study. The results show that: a) individual factors play a dominant role in system risk/performance management, in respect to views of both Safety-I and II; and b) organizational factors are more influential in creating and maintaining system resilience. Based on the findings, possible patterns of integrating the two philosophies are instantiated through mutually complementary application to BTSS. Despite the context of BTSS, this work provides a feasible way of comparing between Safety-I and Safety-II, for beneficial reference of other socio-technical systems.

- **Keywords:** Safety-II; Resilience engineering; Accident; Empirical research

V. Salehi, B. Veitch, M. Musharraf. [*Measuring and improving adaptive capacity in resilient systems by means of an integrated DEA-Machine learning approach.*](#) **102975.**

Resilient systems strive to enhance the safety of complex systems through building and developing adaptive technological and organizational capacities. This study aims at analyzing and improving the level of adaptive capacity in a petrochemical plant by means of an integrated quantitative approach. The data were gathered by a questionnaire whose reliability is examined by statistical methods. To compute and analyze the influence of resilience engineering (RE) indicators, teamwork, and redundancy on adaptive capacity, data envelopment analysis (DEA) method was used. The results indicate that teamwork and redundancy have a positive effect on enhancing the level of adaptive capacity. Multilayer perceptron (MLP), a machine learning approach, was used to estimate the level of adaptive capacity on the basis of a dataset. The results of DEA and MLP approaches are confirmed by statistical methods. To the best of our knowledge, this is the first study that measures quantitatively and improves adaptive capacity by an integrated DEA-MLP approach based on the stress-strain model. The outcomes of this study could assist managers and other decision-makers of complex systems to compute and improve the level of adaptive capacity for coping with upcoming events in abnormal conditions.

- **Keywords:** Resilience engineering (RE); Adaptive capacity; Teamwork; Redundancy; Data envelopment analysis (DEA); Machine learning

Guillermina Andrea Peñaloza, Tarcisio Abreu Saurin, Carlos Torres Formoso. [Monitoring complexity and resilience in construction projects: The contribution of safety performance measurement systems](#). 102978.

Although complexity and resilience are key inter-related characteristics of construction projects, little is known on how to monitor these characteristics and their implications for safety management. This study investigates the contribution of Safety Performance Measurement Systems (SPMS) as a means for monitoring and understanding of sources of complexity and resilience in construction. It is based in three empirical studies carried out in construction projects, two in Chile and one in Brazil. Two main tools were applied in these studies: (i) the Technical, Organizational and Environmental (TOE) framework, focused on complexity; and (ii) the Resilience Assessment Grid (RAG), focused on resilience. Improvement opportunities were identified for existing SPMS. Also, a set of guidelines for the design of SPMS emerged from these studies as well as a model that explains the connections between the main constructs encompassed by the guidelines.

- **Keywords:** Resilience engineering; Project complexity; Safety performance measurement systems

SPECIAL SECTION: 50 YEARS OF APPLIED ERGONOMICS

Francesco Scotto di Luzio, Clemente Lauretti, Francesca Cordella, Francesco Draicchio, Loredana Zollo. [Visual vs vibrotactile feedback for posture assessment during upper-limb robot-aided rehabilitation](#). 102950.

Repetitive and intensive exercises during robot-aided rehabilitation may expose patients to inappropriate and unsafe postures. The introduction of a sensory feedback can help the subject to perform the rehabilitation task with an ergonomic posture. In this work, the introduction of visual and vibrotactile feedback in a robotic platform for upper limb rehabilitation has been proposed to ensure ergonomic posture during rehabilitation. The two feedback modalities have been used to provide information about incorrect neck and trunk posture. Ten healthy subjects have been involved in this study. Each of them performed 3D reaching movements with the aid of the robotic platform in three different conditions, i.e. without feedback, with visual feedback and with vibrotactile feedback, and a comparative analysis has been carried out to evaluate feedback effectiveness,

acceptance and performance. Experimental results show that in case of no feedback the subjects reach and maintain configurations that can lead to incorrect neck and trunk configurations and therefore, if repeated, to musculoskeletal disorders. Conversely, with visual or vibrotactile feedback, the subjects tend to correct inappropriate posture with both trunk and head during task performing.

- **Keywords:** Upper-Limb Robot-Aided Rehabilitation; Assistance-as-needed; Sensory feedback; Ergonomic posture

Nathalie Bonnardel, Nicolas Pichot. [Enhancing collaborative creativity with virtual dynamic personas](#). 102949.

In many sectors, designers have to develop products that are creative, and thus both new and adapted to the context. They can use a variety of methods to favor their creative design activities, including a new one that we have developed, featuring dynamic personas. This method allows participants to interact in real time in a virtual space with an avatar that represents an archetypal future user and provides them with information about this future user throughout the interactions. In the present experimental study, we compared this method with the classic (or static) persona method, by asking 102 participants to perform a creative design task. Results revealed statistical differences between the use of the static and dynamic persona methods, and highlighted the advantages of the dynamic method over the static one. We discuss the prospects for using this method in an ecological setting and identify the aspects to be improved.

- **Keywords:** Design; Creativity; Personas

Anjum Naweed. [Getting mixed signals: Connotations of teamwork as performance shaping factors in network controller and rail driver relationship dynamics](#). 102976.

Signal passed at danger (SPAD) events have been a perennial issue in rail and requires continued scholarship. Much of the literature has tended to focus on activities within the train cab, placing the spotlight on "error" within the rail driving role; however a train is not propelled by a single person but by a team. This study set out to understand how network controllers perceive the relationship dynamic between the network controller and rail driver, and how these views shape system performance. Using a phenomenological approach underpinned by Joint Cognitive Systems theory, interviews were conducted with network controllers (N = 55) across 8 rail organisations in Australia and New Zealand to examine how they related to signals and to drivers. Sixteen different perspectives were identified ranging in type and varying by frequency, each with implications for coupling strength between the controller and driver roles and on system performance. Key dimensions of teamwork in train movement were emphasised, illustrating how the underlying values and philosophies in different network controlling cultures influence risk perception. The findings may be used to develop a more informed understanding of the 'controller-signal-driver-train' system and pave the way for strategies that can embrace diversity in different perspectives whilst optimizing system safety and performance.

- **Keywords:** Network controllers; Team dynamics; Rail drivers; SPAD-Risk; Complexity

SPECIAL SECTION: CONSIDERING SEX AND GENDER IN ERGONOMICS: EXPLORING THE "HOWS" AND "WHYS"

Alexander Cui, Kim Emery, Anne-Sophie Beaudoin, Jessica Feng, Julie N. Côté. [*Sex-specific effects of sitting vs standing on upper body muscle activity during text typing.*](#) **102957.**

Standing computer work is increasingly popular. However, despite the higher rates of computer work-related disorders in women, no studies have compared how standing work affects men and women. Twelve males and 12 females completed 90-min typing tasks in each posture while electromyography (EMG) data was recorded from eight muscles of the upper body. Results show that females had significantly higher EMG root-mean-squared (RMS) values in the anterior deltoid than males when seated, but higher EMG RMS in the medial trapezius than males when standing ($SBC \leq 0.05$). In standing, they also had lower values than males in the erector spinae. Overall, standing elicited less activity in the upper trapezius, wrist extensors and erector spinae than sitting. Results suggest that the standing posture is generally less muscularly demanding than the seated one, although men and women's neck/shoulder musculature responds differently to the same task performed while seated or standing.

- **Keywords:** Computer work; Posture; Sex; Electromyography

Marie Laberge, Vanessa Blanchette-Luong, Arnaud Blanchard, H el ene Sultan-Taieb, Jessica Riel, Val erie Lederer, Johanne Saint-Charles, C eline Chatigny, M elanie Lefran ois, Jena Webb, Marie- eve Major, Cathy Vaillancourt, Karen Messing. [*Impacts of considering sex and gender during intervention studies in occupational health: Researchers' perspectives.*](#) **102960.**

The aim of this article is to examine the impacts of incorporating sex and gender (s/g) analysis in integrated knowledge translation (iKT) initiatives in the field of ergonomics and occupational health. The article presents findings based on a retrospective analysis of twelve intervention-research (IR) studies, including a thematic content analysis of in-depth interviews conducted with 15 researchers involved in these IRs. The findings offer an overview of various categories of impacts, such as changes in partners' views, in workplace settings and conditions, in practices and policies, and in economic outcomes. In these types of IR, health effects measurement is not the main objective, and direct health outcomes are difficult to assess. Explicitly talking about sex/gender led more often to system-level changes but less often to workplace-level changes, compared to interventions where sex/gender was not identified as a specific object of the intervention.

- **Keywords:** Sex and gender-based analysis; Integrated knowledge translation; Ergonomics; Occupational health; Research-intervention studies; Evaluation

N. Busto Serrano, A. Su arez S anchez, F. S anchez Lasheras, F.J. Iglesias-Rodr iguez, G. Fidalgo Valverde. [*Identification of gender differences in the factors influencing shoulders, neck and upper limb MSD by means of multivariate adaptive regression splines \(MARS\).*](#) **102981.**

In the present research, models based on multivariate adaptive regression splines (MARS) are proposed to study the influence of gender in the factors affecting the development of shoulders, neck and upper limb MSD. Two different MARS models, corresponding to men and women, are constructed to identify variables with the strongest effect on the target MSD. Both models are capable to predict successfully the occurrence of the studied disorders. Men seem to be more vulnerable to physical risk factors and some other working conditions, whereas women appear to be more affected

by psychosocial risk factors and activities carried out outside their working hours. According to the results, gender needs to be considered to ensure the success and effectiveness of ergonomic interventions on the whole working population.

- **Keywords:** Musculoskeletal disorders (MSD); Gender; Shoulder; Neck; Upper limb; Multivariate adaptive regression splines (MARS)

SPECIAL SECTION: ADVANCING THEORY AND METHODS IN HUMAN FACTORS/ERGONOMICS FOR HEALTH AND HEALTHCARE: A TRIBUTE TO PROFESSOR BEN-TZION (BENTZI) KARSH

Emily S. Patterson, George Su, Urmimala Sarkar. [Reducing delays to diagnosis in ambulatory care settings: A macrocognition perspective](#). 102965.

We aim to use a macrocognition theoretical perspective to characterize contributors to diagnostic delays by physicians that can be mitigated by work system redesign. As experienced with other complex, sociotechnical domains, system redesign is anticipated to be more effective at improving safety than training-based solutions. In the outpatient care setting, complex tasks, conducted by a primary care provider, are provided for five macrocognition functions: sensemaking, re-planning, detecting problems, deciding, and coordinating. Redesigning systems could reduce delays to diagnosis by helping users to avoid missed symptoms, forgotten follow-up activities, and delayed actions. Health information technology could support resilience strategies by offloading documentation burdens, recording working diagnoses, displaying planned follow-up activities at the correct time interval, and supporting recognition of patterns in patient care. These insights suggest a path forward for future research on system design innovations to reduce diagnostic delays, and ultimately, reduce patient harm.

- **Keywords:** Patient harm; Delayed diagnosis; Medical informatics; Ambulatory care; Human factors

Patricia A. Abbott, Matthew B. Weinger. [Health information technology: Fallacies and Sober realities – Redux A homage to Bentzi Karsh and Robert Wears](#). 102973.

Since the publication of "Health Information Technology: Fallacies and Sober Realities" in 2010, health information technology (HIT) has become nearly ubiquitous in US healthcare facilities. Yet, HIT has yet to achieve its putative benefits of higher quality, safer, and lower cost care. There has been variable but largely marginal progress at addressing the 12 HIT fallacies delineated in the original paper. Here, we revisit several of the original fallacies and add five new ones. These fallacies must be understood and addressed by all stakeholders for HIT to be a positive force in achieving the high value healthcare system the nation deserves. Foundational cognitive and human factors engineering research and development continue to be essential to HIT development, deployment, and use.

- **Keywords:** Clinical informatics; Decision support; User-centered design; Human factors engineering; Systems engineering; HIT; Fallacies; Sober realities; Patient safety

Richard J. Holden, Victor P. Cornet, Rupa S. Valdez. [Patient ergonomics: 10-year mapping review of patient-centered human factors](#). 102972.

Patient ergonomics is the application of human factors or related disciplines to study and improve patients' and other non-professionals' performance of effortful work activities in

pursuit of health goals. We performed a mapping review of 212 full-text patient ergonomics publications in two conference proceedings, 2007–2017. The review revealed a robust and growing body of literature on patient ergonomics, particularly in the areas of aging and chronic disease, tools and technologies, and evaluations of patient-centered interventions on outcomes such as usability, user acceptance, and performance. Findings highlighted gaps deserving future research, including research with understudied populations such as children, informal caregivers, networks and collectives (groups), and marginalized populations; on topics such as health promotion and transitions of care; and using longitudinal and experimental study designs. The growth of patient-centeredness in general and of patient ergonomics in particular compel other more focused reviews, new primary research, and developing a roadmap for future patient ergonomics research.

- **Keywords:** Patient work; Patient engagement; Patient activation; Medical human factors; Patient-centered human factors and ergonomics

Yaar Harari, Raziel Riemer, Eli Jaffe, Oren Wacht, Yuval Bitan. [Paramedic equipment bags: How their position during out-of-hospital cardiopulmonary resuscitation \(CPR\) affect paramedic ergonomics and performance.](#) 102977.

This study investigates how the positions of paramedic equipment bags affect paramedic performance and biomechanical loads during out-of-hospital Cardiopulmonary Resuscitation (CPR). An experiment was conducted in which 12 paramedic teams (each including two paramedics) performed in-situ simulations of a cardiac-arrest scenario. CPR quality was evaluated using five standard resuscitation measures (i.e., pre- and post-shock pauses, and compression rate, depth and fraction). The spinal loads while lifting, pulling and pushing the equipment bags were assessed using digital human modeling software (Jack) and prediction equation from previous studies. The results highlight where paramedics are currently choosing to position their equipment. They also demonstrate that the positions of the equipment bags affect CPR quality as well as the paramedics' work efficiency, physiological effort and biomechanical loads. The spinal loads ranged from 1901 to 4030N; furthermore, every occasion on which an equipment bag was lifted resulted in spinal forces higher than 3400N, thus exceeding the maximum threshold stipulated by the National Institute for Occupational Safety and Health. 72% of paramedics' postures were categorized as high or very high risk for musculoskeletal disorders by the Rapid Entire Body Assessment. Guidelines related to bag positioning and equipment handling might improve CPR quality and patient outcomes, and reduce paramedics' risk of injury.

- **Keywords:** Manual material handling; Paramedics; Ergonomics; CPR quality