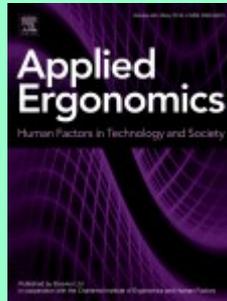


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Jessica A. Dobson, Diane L. Riddiford-Harland, Alison F. Bell, Caleb Wegener, Julie R. Steele. *Effect of shaft stiffness and sole flexibility on perceived comfort and the plantar pressures generated when walking on a simulated underground coal mining surface.*

The structural features of work boots worn by underground coal miners affect comfort, foot motion and, in turn, loading of the plantar surface of miners' feet. Although shaft stiffness and sole flexibility appear to be boot design features that could influence perceived comfort and plantar pressures, no study has systematically altered these boot design features to truly understand how they affect these parameters. This study aimed to systematically investigate the effect of changes to shaft stiffness and sole flexibility on perceived comfort and plantar pressures when 20 males walked on a simulated gravel coal mining surface under four different work boot conditions. There were no significant effects of shaft stiffness or sole flexibility on perceived comfort. However, shaft stiffness and sole flexibility each significantly affected the plantar pressures generated under the medial midfoot, heel, middle metatarsals and hallux and, in combination, affected plantar pressures generated beneath the lateral midfoot, medial and lateral metatarsals and lesser toes. Participants preferred a boot with a flexible shaft combined with a stiff sole, citing properties such as fit, moveability, walking effort and support to explain why they perceived one boot as more comfortable than another. We therefore recommend that underground coal mining work boots should be designed to incorporate different flexibility and stiffness between the shaft and sole of the boot to optimise foot movement and, in turn, walking efficiency.

Eric B. Weston, Jonathan S. Dufour, Ming-Lun Lu, William S. Marras. *Spinal loading and lift style in confined vertical space.*

The objective of this study was to investigate biomechanical loads on the lumbar spine as a function of working in a confined vertical space, consistent with baggage handling inside the baggage compartment of an airplane. Ten male subjects performed baggage handling tasks using confined (kneeling, sitting) and unconfined (stooping) lifting styles. Dependent measures of torso flexion and three-dimensional spinal loads were assessed with an electromyography-driven biomechanical model. Lifting exertions typical to airline baggage handling posed significant risk to the lumbar spine, regardless of lifting style. Statistically significant differences attributable to lift style (stooping, kneeling, sitting) were not observed for peak compressive, lateral shear, or resultant spinal loads, but lifting while kneeling decreased anterior/posterior (A/P) shear spinal loads relative to stooping ($p = 0.02$). Collectively, kneeling offers the greatest benefit when lifting in

confined spaces because of the ability to keep the torso upright, subsequently reducing shear forces on the lumbar spine.

- **Keywords:** Baggage handling; Kneeling; Sitting

Emmanuel Tetteh, Pramiti Sarker, Caleb Radley, M. Susan Hallbeck, Gary A. Mirka. *Effect of surgical radiation personal protective equipment on EMG-based measures of back and shoulder muscle fatigue: A laboratory study of novices.*

Interventional radiologists are at increased risk for musculoskeletal discomfort/disorders and this has been linked to the use of radiation personal protective equipment (rPPE). This study examined the effects of rPPE on the development of fatigue of the erector spinae and trapezius muscles. Surface electromyography (EMG) was used to capture muscle activity, and both time domain (average rectified value) and frequency domain (median frequency) measures were considered in the assessment of localized muscle fatigue. Sixteen participants performed a simulated surgical procedure requiring intermittent 30° flexed static trunk posture with and without rPPE on separate days. The results showed that the rPPE condition demonstrated significantly greater ($p < 0.05$) downward shift in median frequency in the left lumbar erector spinae and left lower thoracic erector spinae consistent with task-induced localized muscle fatigue. Ergonomic intervention strategies are discussed.

- **Keywords:** Cardiovascular surgery; sEMG; Low back pain; Personal protective equipment

Volker Scheer, Solveig Vieluf, Marc Schröder, Pascal Lappe, Hans-Christian Heitkamp. *A comparison of economy between two different backpack designs for runners.*

We compared two backpack designs (back/front or back only) in twelve recreational runners (age 22.0 ± 1.7 years). An initial incremental exercise test (VO_{2max} 52.2 ± 4.7 ml $kg^{-1} \cdot min^{-1}$) was conducted, followed by four tests of 20 min duration (running speed 9.8 ± 1.1 km/h) with loads carried of 0, 1 kg, 3 kg, and 6 kg with the two backpack designs in a randomized order. Economy was assessed by energy cost of running (CR), oxygen cost (O₂ cost), heart rate (HR) and rate of perceived exertion (RPE). Repeated measure ANOVA revealed a non-significant main effect for CR, O₂ cost, HR, RPE between systems. Post-hoc comparison of significant time \times position interaction showed for CR, $F(3,33) = 5.34$, $p < .01$, $\eta^2 = 0.33$, and O₂ cost, $F(3,33) = 5.15$, $p < .01$, $\eta^2 = 0.32$, that carrying weight in the back/front were significantly lower after 20 min (CR: $p = .02$ and O₂ cost: $p = .03$). These results suggest, that for longer runs the equal distribution of weight is advantageous.

- **Keywords:** Running economy; Energy cost of running; Oxygen cost; Loaded running; Backpack system

Annabelle Munnik, Katharina Näswall, Graeme Woodward, William S. Helton. *The quick and the dead: A paradigm for studying friendly fire.*

The Sustained Attention to Response Task (SART) is a computer based Go-No-Go response task. Participants respond to frequently occurring neutral stimuli and withhold responses to rare target stimuli. Researchers have suggested the inhibition demands of the SART may mirror those which occur in some firearm accidents. Participants in the present experiment used a simulated nonlethal weapon to subdue threats (images of people holding guns) on large screens. Participants completed a target rich task (high Go low No-Go, like a SART), a target sparse task (low Go/high No-Go), a verbal recall task,

and dual versions of the target rich and target sparse tasks with the verbal recall task as the secondary task. Results provided further evidence that some accidental shootings may result from failures of response inhibition and that additional cognitive load is detrimental to overall performance. Future studies should explore the role of response inhibition in realistic firearm scenarios.

- **Keywords:** fratricide; Friendly-fire; Mindlessness; Motor control; Response inhibition; Sustained attention

Lidewij R. Renaud, Judith G.M. Jelsma, Maaïke A. Huysmans, Femke van Nassau, Jeroen Lakerveld, Erwin M. Speklé, Judith E. Bosmans, Dominique P.M. Stijnman, Anne Loyen, Allard J. van der Beek, Hidde P. van der Ploeg. *Effectiveness of the multi-component dynamic work intervention to reduce sitting time in office workers – Results from a pragmatic cluster randomised controlled trial.*

Objective: Prolonged sitting, which is highly prevalent in office workers, has been associated with several health risks. The aim of this study was to evaluate the Dynamic Work intervention by determining its effect on total sitting time at the 8-month follow-up in comparison to the control. **Methods:** This two-arm pragmatic cluster randomised controlled trial included 244 office workers from 14 different departments of a large, Dutch insurance company. The Dynamic Work intervention was a real-life, worksite intervention that included environmental components (i.e. sit-stand workstations), organisational components (i.e. group sessions), and individual components (e.g. activity/sitting trackers). Outcomes were assessed at baseline, 4-month follow-up, and 8-month follow-up. The primary outcome was total sitting time per day, objectively assessed using the activPAL activity monitor at 8-month follow-up. Secondary outcomes included other total and occupational movement behaviour outcomes, health-related outcomes, and work-related outcomes. Data analyses were performed using linear and logistic mixed models. **Results:** Total sitting time did not differ between the intervention and control group at the 8-month follow-up. Secondary outcomes also showed no difference between the intervention and control group at either the 4-month or at 8-month follow-up, with the exception of number of occupational steps, which showed a statistically significant effect at 4-month follow-up (but not at 8-month follow-up) of 913 (95% CI = 381–1445) steps/8-h working day. **Conclusions:** This study evaluated the effectiveness of a real-life worksite intervention to reduce sitting time and showed little to no effect. This may be due to the relatively low intensity of the intervention, i.e. that it only involved the replacement of 25% of sitting workstations with sit-stand workstations. Future research should focus on the evaluation of more intensive real-life worksite interventions that are still feasible for implementation in daily practice.

- **Keywords:** Real-life practice intervention; Reduce sitting time; Office workers

Irene Di Giulio, Bradford J. McFadyen, Sophie Blanchet, Neil D. Reeves, Vasilios Baltzopoulos, Constantinos N. Maganaris. *Mobile phone use impairs stair gait: A pilot study on young adults.*

Human movement control requires attention to accurately tune motor commands in response to environmental changes. Dual task paradigms are used to test the role of attention on motor performance. Usually the tasks used have little resemblance with every day experience. Here we ask: Does a common cognitive task, such as a mobile phone conversation, compromise motor performance on stairs? Eight young participants negotiated an instrumented seven-step staircase. Stair negotiation while talking on a mobile phone was compared to normal stair negotiation. Stepping parameters, jerk cost (measure of smoothness of locomotion) and step clearance were measured. When talking on a mobile phone, participants' overall body velocity (mean(sd): Ascent 0.534(0.026) vs

0.511(0.024) m/s, Descent 0.642(0.026) vs 0.511(0.024) m/s, No phone/Phone respectively) and cadence decreased significantly (Ascent 75.8(5.8) vs 65.6(4.4) steps/min, Descent 117.4(4.2) vs 108.6(6.0) steps/min, No Phone/Phone respectively). Pelvis and feet jerk cost also changed significantly, mostly decreasing with phone use. Foot clearance did not show significant changes between No Phone and Phone conditions. These pilot results show that, even for young, healthy and cognitively intact individuals, talking on a mobile phone whilst negotiating a staircase induces measurable changes in motor performance. Participants moved slowly but more smoothly, reducing the motor control cost, possibly at the expense of movement accuracy. The reduction in motor performance is likely to be due to the difficulty in integrating the two sub-tasks. These results suggest that even young, healthy individuals show stair gait impairment when simultaneously negotiating stairs and performing another cognitive task, such as talking on the phone.

- **Keywords:** Dual task; Locomotor performance; Control cost; Information processing interference

Ida-Märta Rhén, Mikael Forsman. *Inter- and intra-rater reliability of the OCRA checklist method in video-recorded manual work tasks.*

Observation-based risk assessments are often used for evaluation of biomechanical workload and the condition of the workplace ergonomics. However, the inter- and intra-rater reliability of the methods used for the assessments are insufficiently studied. The OCRA checklist method, included as a reference method in the ISO and CEN standards regarding upper limb repetitive risk assessment, was in this study investigated regarding its reliability. Eleven ergonomists were educated within the method. Each ergonomist risk-assessed ten video-recorded manual work tasks, on two occasions. The average inter-rater agreement of the five overall risk levels was 39% and the linearly weighted kappa was 0.43, the intra-rater dittos were 45% and 0.52. Both indicating a moderate reliability, but lower than what could be expected. The levels might be sufficient for coarse surveys. However, for risk assessments before and after an intervention, complementing technical methods should be considered.

- **Keywords:** Inter-rater reliability; Intra-rater reliability; Risk assessment; Observational methods

Maryam Zahabi, Ashiq Mohammed Abdul Razak, Ashley E. Shortz, Ranjana K. Mehta, Michael Manser. *Evaluating advanced driver-assistance system trainings using driver performance, attention allocation, and neural efficiency measures.*

There are about 44 million licensed older drivers in the U.S. Older adults have higher crash rates and fatalities as compared to middle-aged and young drivers, which might be associated with degradations in sensory, cognitive, and physical capabilities. Advanced driver-assistance systems (ADAS) have the potential to substantially improve safety by removing some of driver vehicle control responsibilities. However, a critical aspect of providing ADAS is educating drivers on their operational characteristics and continued use. Twenty older adults participated in a driving simulation study assessing the effectiveness of video-based and demonstration-based training protocols in learning ADAS considering gender differences. The findings revealed video-based training to be more effective than demonstration-based training in improving driver performance and reducing off-road visual attention allocation and mental workload. In addition, female drivers required lower investment of mental effort (higher neural efficiency) to maintain the performance relative to males and they were less distracted by ADAS. However, male drivers were faster in activating ADAS as compared to females since they were monitoring the status of ADAS features more frequently while driving. The findings of this study provided an empirical support for using video-based approach for learning ADAS in

older adults to improve driver safety and supported previous findings on older adults' learning that as age increases there is a tendency to prefer more passive and observational learning methods.

- **Keywords:** ADAS; Older adults; fNIRS

Maryam Zahabi, Carl Pankok, Junho Park. *Human factors in police mobile computer terminals: A systematic review and survey of recent literature, guideline formulation, and future research directions.*

The objectives of this research were to: (1) identify Mobile Computer Terminal (MCT) human factors issues, (2) formulate guidelines and an enhanced MCT for improving interface design and implementation in police patrols, and (3) identify areas of future research to fill gaps in the literature. A systematic literature search was conducted leading to results categorized in four groups including: productivity, physical discomfort, interface usability, and driving distraction. Although MCT use has increased officer productivity, several usability issues need to be resolved. The MCT has also increased officer physical discomfort and distraction. MCT design and implementation guidelines that resolve human factors issues in police patrols were identified along with an enhanced design concept. Guidelines for MCT design were validated with an online survey completed by 81 police officers. Future research directions were proposed to recognize police officer needs and work context.

- **Keywords:** Productivity; Physical effects; Usability; Driving distraction

Wenyan Huang, Xiaoyu Chen, Ran Jin, Nathan Lau. *Detecting cognitive hacking in visual inspection with physiological measurements.*

Cyber threats are targeting vulnerabilities of human workers performing tasks in manufacturing processes, including visual inspection to bias their decision-making, thereby sabotaging product quality. This article examines the use of priming as a form of "cognitive hacking" to adversely affect quality inspection decisions in manufacturing, and investigates physiological measurements as means to detect such intrusion. In a within-subject design experiment, twenty participants inspected surface roughness of a manufactured component with and without exposure to priming on the display of an inspection logging system. The results show that the presence of primes impacted accuracy on surface roughness, cortical activities at parietal lobe P4, and eye gaze for inspecting components. The experiment provides supporting evidence that basic hacking of a worker display can be an effective method to alter decision making in inspection. The findings also illustrate that cortical activities and eye gaze can be useful indicators of cognitive hacking. A major implication of the study results is that physiological indicators can be effective at revealing unconscious cognitive influence in visual inspection.

- **Keywords:** Additive manufacturing; Cognitive hacking; Cybersecurity; EEG; Eye-tracking; Inspection

Sidney T. Baudendistel, Terry L. Grindstaff, Adam B. Rosen, Jennifer M. Yentes. *Bimanual load carriage alters sway patterns and step width.*

Many workplace falls occur during tasks involving carrying a load with both hands. Successful balance and gait during bimanual load carrying may be attributed to the adaptability of a system to navigate changing environments (e.g. construction site). This study investigates how bimanual load carrying affects adaptability of balance and gait, using 0%, 5%, and 10% of body mass in 14 young adults. Regularity of balance, and measures of range and center of pressure distance, and gait measures of stride length and step width were quantified using sample entropy. When carrying 5% load, anterior-posterior balance became less adaptable relative to 0%. As load increased from 0% to

5%–10%, step width narrowed and variability increased significantly, indicating possible increased fall risk while walking. Healthy, young adults may be at an increased risk of falls when carrying a load due to a loss in adaptability in a dynamic workplace environment.

- **Keywords:** Load carrying; Gait; entropy

Chris Malbon, Dr Clare Knock, Dr Richard Critchley, Prof Debra J Carr. *The effect of breast size and bra type on comfort for UK female police officers wearing body armour.*

Within the Police service of England and Wales the wearing of ballistic and stab resistant body armour is common, with most police forces mandating its usage when away from the police station. Of all the serving police officers in England and Wales 29.1% are female (Hargreaves et al., 2017). A survey was developed and then distributed by the Police Federation of England and Wales to all servicing police officers up to the rank of Inspector. The survey returned 2633 responses after cleaning of the data. From the responses it was seen that the predominant bra type worn is underwired (71%) and the predominant UK bra size is 34B (9%). It was also determined that the predominant areas where the body armour either rubbed or caused discomfort were the left and right anterior mammary regions and the posterior lateral sacral region. By understanding the distribution of bra size, type of bra worn and areas of discomfort or rubbing it helps further understand the issues faced by female police officers and how body armour design could be improved.

- **Keywords:** UK bra size; Sports bra; Underwired bra; Activity

Sai Akhil Penumudi, Veera Aneesh Kuppam, Jeong Ho Kim, Jaejin Hwang. *The effects of target location on musculoskeletal load, task performance, and subjective discomfort during virtual reality interactions.*

The objective of this study was to evaluate the effect of different target locations on musculoskeletal loading and task performance during virtual reality (VR) interactions. A repeated-measures laboratory study with 20 participants (24.2 ± 1.5 years; 10 males) was conducted to compare biomechanical exposures (joint angle, moment, and muscle activity in the neck and shoulder), subjective discomfort, and task performance (speed and accuracy) during two VR tasks (omni-directional pointing and painting tasks) among different vertical target locations (ranged from 15° above to 30° below eye height). The results showed that neck flexion/extension angle and moment, shoulder flexion angle and moment, shoulder abduction angle, muscle activities of neck and shoulder muscles, and subjective discomfort in the neck and shoulder significantly varied by target locations (p 's < 0.001). The target locations at 15° above and 30° below eye height demonstrated greater shoulder flexion (up to 52°), neck flexion moment (up to 2.7Nm), anterior deltoid muscle activity, and subjective discomfort in the neck and shoulder as compared to the other locations. This result indicates that excessive vertical target locations should be avoided to reduce musculoskeletal discomfort and injury risks during VR interactions. Based on relatively lower biomechanical exposures and trade-off between neck and shoulder postures, vertical target location between eye height and 15° below eye height could be recommended for VR use.

- **Keywords:** Virtual environment; Hand gestures; Head-mounted display; Task performance

SPECIAL SECTION ON COMFORT; EDITED BY PETER VINK, SUSANNE FROHRIEP, NEIL J MANSFIELD & ALESSANDRO NADDEO

Gabriel H. Campos, Fengfeng (Jeff) Xi. *Pressure sensing of an aircraft passenger seat with lumbar control.*

Musculoskeletal sitting discomfort, specifically caused by long-term sitting, is primarily triggered by physiological fatigue on the human body due to its own weight. Passive seat designs can produce inadequate surface pressure zones on the body resulting in high musculoskeletal stress leading to physical discomfort. However, as proposed in this work, this can be alleviated by decentralizing the occupant's weight with an automatic morphing lumbar seat design. The morphing seat design presented in this paper adjusts in real-time, the seat's surface curvature to decentralize the pressure distribution. The seat system consists of a custom-made pressure sensor mat embedded within the backrest cushion and two pneumatic actuators located in the lumbar area. The purpose of this seat design is to produce a change in the backrest surface curvature so that such change creates a pressure distribution closely resembling a reference distribution. Said reference distribution is derived in this work based on the concept of the Ideal Pressure Distribution. The effectiveness of the discomfort reduction due to the decentralization of the backrest load is evaluated using an objective discomfort metric known as Seat Pan Distribution percentage applied only to the backrest, peak pressure areas and contact area. Preliminary performance tests of the seat system demonstrate the successful decentralization of the passenger's pressure distribution. The evaluation of the discomfort reduction is observed via the lowering in the objective discomfort metric and peak pressure areas while simultaneously increasing the contact area between the passenger and seat.

- **Keywords:** Seat design; Pressure sensing; Morphing seat; Ideal pressure distribution; Backrest; Aircraft seat; Lumbar control

M. Wegner, R. Martic, M. Franz, P. Vink. *A system to measure seat-human interaction parameters which might be comfort relevant.*

In this paper a measurement tool is described and tested to evaluate the characteristics of different elements of a seat. Many studies report a relationship between discomfort and pressure distribution, but it is unknown what exactly is happening in the interaction. The purpose of this study is to present a measuring device, which records the comfort relevant seat parameters pressure and elongation while loading a seat. The results of the study, including the repeatability, reproducibility and detectability show that the measurement method is appropriate for our purpose, although the reproducibility has to be improved by operator experience or by a more intuitive assembling of the measurement setup. An application example illustrates that the interaction of the seat components highly affect the resulting comfort relevant parameters. The question is whether this objectively recorded differences are also experienced by seat occupants, which is interesting to study in future research.

- **Keywords:** Measurement method; Objective seat comfort; Seat characterization; Comfort relevant parameter

Eunyeong Kim, Mohammad Fard, Kazuhito Kato. *A seated human model for predicting the coupled human-seat transmissibility exposed to fore-aft whole-body vibration.*

Occupant discomfort, induced by vibration transmitted through a vehicle seat, can be evaluated by measuring vibration on the contact interface between the occupant and seat. In the previous study (Ittianuwat et al., 2016), measuring five contact points of the

back-backrest, including centre point (ISO 2631-1), was considered as an important factor for assessing occupant comfort in frequencies where seat structure resonances occur. To enhance occupant vibration comfort in the early seat design stage, predicting the dynamic response of the coupled human-seat system on various contact locations is necessary. In this study, a low order seated human body Finite Element (FE) model was developed for predicting vibration transmissibility of the human-seat system in frequencies up to 30 Hz. Throughout the optimization process, the parameters of the model were obtained by comparing measured transmissibilities of the occupied vehicle seat system. The human-seat system vibration modes were also compared and verified with measured data by calculating MAC (Modal Assurance Criterion). The results showed that two human body vibration modes coupled with foam were observed below 10 Hz, and two coupled human and seat structure fore-aft modes were observed at around 20.1 Hz and 21.9 Hz. Fore-aft transmissibility of the model at various locations of contact provided reasonable correlation with the measured data. The developed low order human model enables the prediction of the fore-aft transmissibility on various back-backrest contact locations up to 30 Hz. This showed the capability of improving occupant's vibration comfort by predicting transmissibilities of the human-seat system in the early stage of developing a new vehicle seat.

- **Keywords:** Human-seat system; Finite element modelling; Transmissibility; Resonance frequency; Mode shape; Whole-body vibration

SPECIAL SECTION ON ADVANCING THEORY AND METHODS IN HUMAN FACTORS/ERGONOMICS FOR HEALTH AND HEALTHCARE: A TRIBUTE TO PROFESSOR BEN-TZION (BENTZI) KARSH EDITED BY ASSIST. PROF. RUPA VALDEZ, DR. A. JOY RIVERA AND DR. RICHARD J. HOLDEN

Maureen A. Smith, Peter A. Nordby, Menggang Yu, Jonathan Jaffery. *A practical model for research with learning health systems: Building and implementing effective complex case management.*

For researchers to contribute meaningfully to the creation of learning health systems, practical tools are required to operationalize existing conceptual frameworks. We describe a model currently in use by the University of Wisconsin Health Innovation Program (HIP). The HIP model consolidates and enhances existing learning health system frameworks by defining specific steps needed to create sustainable change based on research conducted within the health system. As an example of the model's application, we describe its use to improve patient identification for the University of Wisconsin health system's case management program. Our case study shows the importance of culture, infrastructure, and strong leadership support in realizing a learning health systems research project and creating sustainable change within the health system. By articulating the foundational elements and steps to conduct research with learning health systems, our model supports researchers in achieving the challenge of moving learning health systems from concept to action.

- **Keywords:** Learning health systems; Health services research; Case management

Priyadarshini R. Pennathur. *A Theoretical Framework for Understanding Creator-Consumer Information Interaction Behaviors in Healthcare Documentation Systems.*

The advent of electronic documentation systems has made it easy to generate and store vast amounts of information, and has enabled easy access to patient care information, so

much so that they are now considered a critical infrastructure for supporting the cognitive tasks in healthcare work. But, electronic documentation systems are not without their share of problems. Accountability and liability requirements have made electronic information creation and documentation particularly challenging. Mandatory documentation requirements and templated electronic formats have increased the amount of information, but have not always resulted in reliable, useful, or meaningful information. Documentation systems have become rigid, offering little opportunity for healthcare providers to engage in meaningful conversations about the information, and to sense problem status without additional coordination. A particularly significant information interaction problem that we have identified from our field work in healthcare information modeling, which this paper focuses on, deals with what we term creator-consumer interaction behaviors. The purpose of this paper is to examine in-depth the problem of creator-consumer information interaction behaviors in electronic healthcare documentation systems. A creator-consumer interaction behavioral framework highlights satisficing behavior during creation and consumption of medical documentation, and the characteristics of the work system that may lead to satisficing on documentation tasks.

- **Keywords:** Documentation; Electronic health records; Satisficing; Information; Safety

Jonathan L. Temte, John W. Beasley, Richard J. Holden, Ben-Tzion Karsh, Beth Potter, Paul Smith, Peggy O'Halloran. *Relationship between number of health problems addressed during a primary care patient visit and clinician workload.*

Introduction: Primary care is complex due to multiple health problems being addressed in each patient visit. Little is known about the effect of the number of problems per encounter (NPPE) on the resulting clinician workload (CWL), as measured using the National Aeronautics and Space Administration Task Load Index (NASA-TLX). **Methods:** We evaluated the relationship between NPPE and CWL across 608 adult patient visits, conducted by 31 clinicians, using hierarchical linear regression. Clinicians were interviewed about outlier visits to identify reasons for higher or lower than expected CWL. **Results:** Mean NPPE was 3.30 ± 2.0 (sd) and CWL was 47.6 ± 18.4 from a maximum of 100. Mental demand, time demand and effort accounted for 71.5% of CWL. After adjustment for confounders, each additional problem increased CWL by 3.9 points ($P < 0.001$). Patient, problem, environmental and patient-physician relationship factors were qualitatively identified from interviews as moderators of this effect. **Conclusion:** CWL is positively related to NPPE. Several modifiable factors may enhance or mitigate this effect. Our findings have implications for using a Human Factors (HF) approach to managing CWL.

Pascale Carayon, Abigail Wooldridge, Peter Hoonakker, Ann Schoofs Hundt, Michelle M. Kelly. *SEIPS 3.0: Human-centered design of the patient journey for patient safety.*

The Systems Engineering Initiative for Patient Safety (SEIPS) and SEIPS 2.0 models provide a framework for integrating Human Factors and Ergonomics (HFE) in health care quality and patient safety improvement. As care becomes increasingly distributed over space and time, the "process" component of the SEIPS model needs to evolve and represent this additional complexity. In this paper, we review different ways that the process component of the SEIPS models have been described and applied. We then propose the SEIPS 3.0 model, which expands the process component, using the concept of the patient journey to describe the spatio-temporal distribution of patients' interactions with multiple care settings over time. This new SEIPS 3.0 sociotechnical systems approach to the patient journey and patient safety poses several conceptual and methodological challenges to HFE researchers and professionals, including the need to

consider multiple perspectives, issues with genuine participation, and HFE work at the boundaries.

- **Keywords:** SEIPS; Patient journey; Care coordination; Human-centered design; Participatory ergonomics; Patient safety

SPECIAL SECTION: CONSIDERING SEX AND GENDER IN ERGONOMICS: EXPLORING THE "HOWS" AND "WHYS"; EDITED BY DR. MARIE LABERGE, DR. SANDRINE CAROLY AND DR. JESSICA RIEL

Lucas Gomes Miranda Bispo, Jonhatan Magno Norte da Silva, Ivan Bolis, Wilza Karla dos Santos Leite, Elamara Marama de Araujo Vieira, Geraldo Alves Colaço, Erivaldo Lopes de Souza, Leila Amaral Gontijo, Luiz Bueno da Silva. *Effects of a worksite physical activities program among men and women: An interventional study in a footwear industry.*

The study aims to assess the association between various levels of engagement in a worksite physical activities program and variables related to musculoskeletal symptoms, psychophysiological well-being, difficulty to perform tasks, willingness to work, and interpersonal relationships, among men and women in a footwear industry. This program involved 1113 workers. Data were analysed using an ordinal logistic regression model. In women, an increase in the frequency of participation in the worksite physical activities program was associated with less musculoskeletal pain (OR = 3.12; 2.07–4.71), better relationships among colleagues (OR = 2.83; 1.67–4.81), and a higher level of psychophysiological well-being (OR = 1.98; 1.06–3.70). In men, an increase in the frequency participation in the worksite physical activities program was associated with less difficulty in performing occupational tasks (OR = 0.49; 0.27–0.87). Thus, the association between occupational exercises and studied variables differed between genders.

- **Keywords:** Perception; Worker's health; Worksite physical activities programme

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

Simone Borsci, Peter Buckle, Simon Walne. *Is the LITE version of the usability metric for user experience (UMUX-LITE) a reliable tool to support rapid assessment of new healthcare technology?*

Objective: To ascertain the reliability of a standardised, short-scale measure of satisfaction in the use of new healthcare technology i.e., the LITE version of the usability metric for user experience (UMUX-LITE). Whilst previous studies have demonstrated the reliability of UMUX-LITE, and its relationship with measures of likelihood to recommend a product, such as the Net Promoter Score (NPS) in other sectors no such testing has been undertaken with healthcare technology. **Materials and methods:** Six point-of-care products at different stages of development were assessed by 120 healthcare professionals. UMUX-LITE was used to gather their satisfaction in use, and NPS to declare their intention to promote the product. Inferential statistics were used to: i) ascertain the reliability of UMUX-LITE, and ii) assess the relationship between UMUX-LITE and NPS at different stages of products development. **Results:** UMUX-LITE showed an acceptable reliability ($\alpha = 0.7$) and a strong positive correlation with NPS ($r = 0.455$, $p < .001$). This

is similar to findings in other fields of application. The level of product development did not affect the UMUX-LITE scores, while the stage of development was a significant predictor ($R^2 = 0.49$) of the intention to promote. **Discussion and conclusion:** Practitioners may apply UMUX-LITE alone, or in combination with the NPS, to complement interview and 'homemade' scales to investigate the quality of new products at different stages of development. This shortened scale is appropriate for use in the context of healthcare in which busy professionals have a minimal amount of time to support innovation.

- **Keywords:** Usability; Satisfaction; Point-of-care systems; In-vitro diagnostics; UMUX; UMUX-LITE; Net promoter score; Technology readiness level

Patrick Waterson. *Causation, levels of analysis and explanation in systems ergonomics: A Closer Look at the UK NHS Morecambe Bay investigation.*

This paper extends an earlier examination of the concept of 'mesoergonomics' (Karsh et al., 2014) and its application to Human Factors/Ergonomics (HFE). Karsh et al. (2014) developed a framework for mesoergonomic inquiry based on a set of steps and questions, the purpose of which was to encourage researchers to cross system levels in the studies (e.g., organisation-group-individual levels of analysis) and to explore alternative causal mechanisms and relationships within their data. The present paper further develops the framework and draws on previous work across a diverse range of sources (safety science, systems theory, the sociology of disaster and ethology) which has examined the subject of accident causation, levels of analysis and explanatory factors contributing to system failure. The outcomes from this exercise are a revised framework which seeks to explore what we term 'isomorphisms' and includes questions covering: (a) how internal isomorphisms develop or evolve within the system; and, (b) how these isomorphisms are shaped by cultural, professional and other forms of external influence. The workings of the revised framework are illustrated through using the example of the UK NHS Morecambe Bay Investigation (Kirkup, 2015). The paper concludes with a summary of ways forward for the framework, as well as new directions for theory within systems ergonomics/human factors.

- **Keywords:** Systems ergonomics; Mesoergonomics; Causality and human factors/ergonomics

SPECIAL SECTION: 50 YEARS OF APPLIED ERGONOMICS; EDITED BY PATRICK DEMPSEY, JIA-HUA LIN AND SARAH SHARPLES

Craig K. Allison, Neville A. Stanton. *Ideation using the "Design with Intent" toolkit: A case study applying a design toolkit to support creativity in developing vehicle interfaces for fuel-efficient driving.*

Everyday driving is a significant source of greenhouse gases and pollutants within developed nations. Finding ways to combat these emissions and minimise the impact of anthropometric climate change is a growing challenge for all research disciplines. This current paper explores the use of a design toolkit "Design with Intent" to generate ideas for in-vehicle interfaces designed to reduce fuel use and emissions. A preliminary interface validation assessment is also presented in order to assess whether the ideas generated were appropriate in encouraging behavioural change and of potential value. It is suggested that whilst further evaluation of the interfaces are required, the use of the "Design with Intent" toolkit facilitated the creative process, allowing engineers to conceive initial interface designs in a creative manner.

- **Keywords:** Design toolkit; Fuel efficient driving; Interface design; Ideation

SPECIAL SECTION ON RESILIENCE ENGINEERING; EDITED BY PROF. SUSAN HALLBECK, DR. RENALDO BLOCKER, DR. KATHERINE LAW AND DR. SHAWNA PERRY

Changwon Son, Farzan Sasangohar, Timothy J. Neville, S. Camille Peres, Jukrin Moon. *Evaluation of work-as-done in information management of multidisciplinary incident management teams via Interaction Episode Analysis.*

Multidisciplinary incident management teams (IMTs) are required to operate in resilient ways as emergency situations unfold unexpectedly. Although resilience in emergency management has been widely studied in many emergency contexts, the development of a new method to investigate actual resilient performance of the IMTs under realistic settings has been limited. To address such gap, this paper first introduces Interaction Episode Analysis (IEA), a novel approach to capture and describe emergent team performance. As an exploratory observation study, we apply the IEA to an information management aspect of the IMTs in two emergency exercises carried out in a high-fidelity environment. As a result, the IEA provides comparable sets of episodes as instances of work-as-done, rendering opportunities to further analyze essential elements of interactions between team members as well as information management activities. Moreover, the IEA enables comparisons between the observations and identification of challenges faced by the team in managing incident information and adaptive behaviors used to address the challenges. By gathering more evidences as well as addressing limitations identified in this study, the IEA is expected to serve as a method that facilitates the analysis of work-as-done of complex team work and the reconciliation between work-as-done and work-as-imagined to promote resilience in emergency management.

- **Keywords:** Emergency response; Resilience engineering; Episode analysis; Work-as-done