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**Changwon Son, Farzan Sasangohar, S. Camille Peres & Jukrin Moon. *Muddling through troubled water: resilient performance of incident management teams during Hurricane Harvey*. Pages: 643-659.**

Modern communities face escalating threats from natural disasters. Thus, the resilience of incident management teams (IMTs) during adverse events becomes crucial to protect lives and physical systems. However, prior studies have only partially highlighted factors related to IMT resilience. To provide a holistic understanding of the resilience of the IMTs, this study conducted semi-structured interviews with 10 experienced IMT personnel during Hurricane Harvey. Thematic analysis revealed six characteristics of resilient IMTs during a hurricane event: (i) establishing a common operating picture, (ii) adopting and adapting plans and protocols, (iii) proactive, re-prioritizing, and unconventional decision-making, (iv) enhancing resourcefulness and redundancy, (v) learning for improved anticipation and response readiness, and (vi) inter-organisational relationship to promote IMT functions. As an empirical investigation of the resilience of the IMTs, the findings inform future endeavours for developing incident information technologies and strategies to harmonise pre-established plans with adaptive actions in the field and fostering capabilities to learn from incidents. **Practitioner summary:** Resilient incident management teams establish a common operating picture; effectively adopt and adapt plans and protocols; make decisions in an unconventional and anticipatory fashion; constantly re-prioritize goals and tasks; enhance resourcefulness and redundancy; continuously learn skills for improved anticipation and response readiness; and exhibit good inter-organisational coordination and planning skills.

- **Keywords:** Resilience, emergency management, hurricane, joint cognitive system

**Dunxing Wang, Qin Gao, Haibo Tan, Zhaopeng Liu, Liwei Zhou, Liu Jia & Zhizhong Li. *Coordination breakdowns in nuclear power plant control rooms: cause identification and behaviour-sequence analysis*. Pages: 660-681.**

This study aims to identify the causes of coordination breakdowns among control crews and to understand their coordination-behaviour patterns during emergencies in nuclear power plants (NPPs). On the basis of in-depth interviews with 18 control-crew operators,

we identified 25 causes of coordination breakdown related to work processes, personnel, and situation and organisation. In addition, we observed 12 control-crew training sessions that dealt with emergencies and conducted lag-sequential analysis. The levels of coordination effectiveness were evaluated using the proportion of coordination breakdowns and the anticipation ratio. We found that higher-performing teams exhibited more non-random coordination behavioural patterns than did lower-performing teams. Coordination-behaviour patterns specific to the higher-performing teams included adaptive workload management (from senior operators) and proactive seeking performance monitoring (from junior operators). The findings of the study enrich our understanding of the critical factors and processes that influence coordination effectiveness of NPP control crews. **Practitioner summary:** Causes of coordination breakdowns among control crews of NPPs were identified based on in-depth interviews with control-crew operators, and behavioural-pattern analysis of control crews in 12 training sessions were analysed to reveal the patterns that differentiate higher- and lower-performing teams. The findings of the study enrich our understanding of the critical factors and processes that influence the coordination effectiveness of NPP control crews.

- **Keywords:** Team coordination, behaviour sequence, control crew, nuclear power plant

**Abdulrahman A. Alhaider, Nathan Lau, Paul B. Davenport & Melanie K. Morris. *Distributed situation awareness: a health-system approach to assessing and designing patient flow management.* Pages: 682-709.**

Patient flow management is a system-wide process but many healthcare providers do not integrate multiple departments into the process to minimise the time between treatments or medical services for maximum patient throughput. This paper presents a case study of applying Distributed Situation Awareness (DSA) to characterise system-wide patient flow management and identify opportunities for improvements in a healthcare system. This case study employed a three-part method of data elicitation, extraction, and representation to investigate DSA. Social, task, and knowledge networks were developed and then combined to characterise patient flow management and identify deficiencies of the command and control centre of a healthcare facility. Social network analysis provided centrality metrics to further characterise patient flow management. The DSA model helped identify design principles and deficiencies in managing patient flow. These findings indicate that DSA is promising for analysing patient flow management from a system-wide perspective. **Practitioner summary:** This article examines Distribution Situation Awareness (DSA) as an analysis framework to study system-wide patient flow management. The DSA yields social, task, and knowledge networks that can be combined to characterise patient flow and identify deficiencies in the system. DSA appears promising for analysing communication and coordination of complex systems.

- **Keywords:** Patient flow, command and control, distributed situation awareness, healthcare management

**Matthew Woodward, Nicholas De Pennington, Carly Grandidge, Peter McCulloch & Lauren Morgan. *Development and evaluation of an electronic hospital referral system: a human factors approach.* Pages: 710-723.**

Coordinating care across hospitals has been identified as a patient safety risk as referrals are often paper-based and poorly documented. Electronic referral systems have the potential to improve the situation but can fail to gain uptake. We applied a human factors/ergonomics (HFE) approach to place analysis of local workflow and user engagement central to the development of a new regional electronic referral system. The intervention was evaluated with a before-and-after study. Referral quality improved,

referrals containing sufficient clinical information for continuation of care increased from 36.9% to 83.5% and completeness of referral information significantly improved. There was a 35.7% reduction in the number of calls to the on-call specialist, and the mean period between admission and surgery for expedited transfers was reduced. Applying HFE informed design with use-based evidence; the system maintains sustained uptake three years after implementation. Reliable recording of information translates to better patient safety during inter-hospital transitions. **Practitioners summary:** This study developed, implemented and evaluated a clinical referral system using a human factors approach. Process analysis and usability studies were used to inform the application requirements and design. Region-wide implementation in hospitals resulted in the improved quality and completeness of clinical referral information and efficiencies in the referral process.

- **Keywords:** Hospital referral, human factors, ergonomics, quality improvement, health information technology

**Elizabeth Salt, Amanda T. Wiggins, Mary Kay Rayens, Quenten Hooker, Iman Shojaei & Babak Bazrgari. *The relationship between indicators of lumbo-pelvic coordination and pain, disability, pain catastrophizing and depression in patients presenting with non-chronic low back pain.* Pages: 724-734.**

This study examined associations and changes overtime in low back kinematics and disability, pain, pain catastrophizing, and depression and assessed whether associations and changes overtime varied between individuals who meet the classification criteria for chronic low back pain at 6 months and those who do not. Findings suggested that those persons with a higher ratio of lumbar contribution to thorax motion and smaller pelvic tilt during forward bending had higher scores on measures of disability, pain and pain catastrophizing. This same association was found in those who met classification criteria for chronic low back pain at 6 months. Opposing associations were found in the group not meeting classification criteria for chronic low back pain, specifically, increased pelvic tilt was positively associated with higher pain catastrophizing scores. **Practitioner summary** This study examined associations and changes overtime in low back kinematics and psychosocial and clinical factors and whether associations and changes overtime varied between individuals who meet the classification criteria for chronic low back pain at 6 months and those who do not, Results suggest that associations exist between psychological factors and kinematic changes during the time between an acute low back pain episode to meeting classification for chronic low back pain at 6 months.

- **Keywords:** Low back pain, kinematics, pain catastrophizing, depression, disability

**Yumeng Yao, Subhash Rakheja & Pierre Marcotte. *Distributed vibration isolation and manual dexterity of anti-vibration gloves: is there a correlation?* Pages: 735-755.**

This study focuses on the integrated performance of anti-vibration (AV) gloves in terms of manual dexterity and distributed palm and fingers' vibration transmissibility. Experiments were designed to measure vibration transmission and manual dexterity performance of 10 different gloves using 15 subjects. The results showed all gloves impeded manual dexterity, while five gloves satisfied the AV glove screening criteria. Glove type yielded a significant effect on manual dexterity ( $p < 0.001$ ) and vibration transmissibility ( $p \leq 0.001$ ). Manual dexterity decreased nearly linearly with an increase in glove thickness ( $p < 0.05$ ), while palm and fingers' vibration transmissibility in high-frequency range was negatively correlated with glove thickness ( $R^2 > 0.70$ ). A strong correlation was evident between glove material stiffness and the H-frequency range palm vibration transmissibility ( $R^2 \geq 0.8$ ). While the vibration isolation of a glove is strongly related to material properties at the palm, the dexterity performance is dependent on

design factors such as thickness and bulkiness. **Practitioner summary:** Anti-vibration gloves are used to isolate hand from power tools vibration, while these may adversely affect manual dexterity. Vibration isolation was correlated with material properties and thickness, while dexterity was correlated with thickness alone. Glove thickness is a vital parameter for realising a compromise between vibration isolation and manual dexterity.

- **Keywords:** Anti-vibration gloves, manual dexterity, vibration transmissibility, AV glove material properties

**Gemma M. Gea-García, Alejandro Espeso-García, Pablo J. Marcos-Pardo & Ruperto Menayo-Antúnez. *Fin type and flutter technique: a study to optimise the oxygen consumption in divers.* Pages: 756-768.**

The purpose of this research was to assess the variability of the oxygen consumption ( $VO_2$ ) depending on fin type and the flutter technique used for the different divers' profile. Twenty-three SCUBA divers took part in four 2.5 hour sessions to evaluate a total of six fin models and two flutter techniques. The flutter routines lasted 30 minutes per fin and per technique. Measurements of  $VO_2$  significantly decreased on Jet ( $20.42 \text{ ml} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$ ) and XShot fin ( $20.87 \text{ ml} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$ ) compared to Twin Jet fin ( $22.81 \text{ ml}$ ,  $p < 0.05$ ). In addition, the  $VO_2$  was in all cases higher in certified divers than in professional divers ( $23.87$  and  $19.00 \text{ ml} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$ ,  $p = 0.00$ ). These differences were significant between divers' profile and flutter technique ( $p < 0.05$ ). Similarly, measurements of  $VO_2$  were higher in frog kick technique than crawl kick technique ( $22.97 \text{ ml} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$  and  $19.96 \text{ ml} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$ ,  $p = 0.00$ ). These differences were significant between fin type and flutter technique in all fins ( $p = 0.03$ ). **Practitioner summary:** This study investigated the impact of fin type, flutter technique and divers' profile on  $VO_2$  during diving. Results of this research suggest that combination a diving different factors significantly impacts the divers'  $VO_2$ , thus providing new perspective for election of fin type and flutter technique according to the divers' profile.

- **Keywords:** Recreational divers, fins, swimming routine, SCUBA dive, oxygen consumption

**Frank Westerhuis, Anselm B. M. Fuermaier, Karel A. Brookhuis & Dick de Waard. *Cycling on the edge: the effects of edge lines, slanted kerbstones, shoulder, and edge strips on cycling behaviour of cyclists older than 50 years.* Pages: 769-786.**

To prevent single-bicycle crashes, this study is the first to evaluate effects of slanted kerbstones, edge lines, shoulder strips, and edge strips on cycling behaviour of cyclists  $\geq 50$  years. In Experiment 1, 32 participants cycled on a control path and paths with edge lines, slanted kerbstones, and three types of 0.5 m wide shoulder strips (with grey artificial grass, green artificial grass, or concrete street-print). In Experiment 2, 30 participants cycled a different route including a control path and paths with edge lines or 0.3 m white edge strips. Cyclists rode closer to the main cycle path's edge in the shoulder strips conditions, although the presence of these strips resulted in a larger total distance to the verge compared to the control condition. Furthermore, cyclists cycled further from the verge in the edge strip condition than the control condition. Safety implications of the shoulder and edge strips are considered to be positive. **Practitioner Summary:** Older cyclists have a high risk for single-bicycle crashes (e.g. riding into the verge). In two experiments, cyclists  $\geq 50$  years cycled a route where different treatments were applied on a cycle path. Shoulder and edge strip treatments were related to more efficient path use and safer distances from the verge.

- **Keywords:** Bicycling, safety, ageing, line marking, shoulders