Exploring human factors in the operating room: a protocol for a scoping review of training offerings for healthcare professionals

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ABSTRACT

Introduction Applying human factors principles in surgical care has potential benefits for patient safety and care delivery. Although different theoretical frameworks of human factors exist, how providers are being trained in human factors and how human factors are being understood in vivo in the operating room (OR) remain unknown. The aim of this scoping review is to evaluate the application of human factors for the OR environment as described by education and training offerings for healthcare professionals.

Methods and analysis This scoping review will follow the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews guidelines. MEDLINE, Embase, PsycINFO, CINAHL, Health and Psychosocial Instruments and ERIC databases were searched on August 2020 from inception to identify relevant studies that describe the content, application and impact of human factors training for healthcare professionals or trainees who work in or interface with the OR environment. Titles, abstracts and full texts will be independently screened by two authors for eligible studies. Any disagreements will be resolved by discussion or by a third author when disagreement persists. Study information and training characteristics, such as the training tool used and type of learners and teachers, will be charted and summarised, and key themes in human factors training will be identified. Each training offering will be classified under the appropriate knowledge area(s) of human factors described by the Chartered Institute of Ergonomics & Human Factors (CIEHF). Themes that are not captured by the CIEHF framework will be independently recorded by two authors and included based on group discussion and consensus.

Ethics and dissemination Research ethics board approval is not required for this scoping review. The findings of this study will be disseminated at local and national conferences and will be published in a peer-reviewed journal.

INTRODUCTION

Healthcare is described as a complex and dynamic sociotechnical system, wherein the care delivered is dependent on the behaviours and actions of providers and the design of the system they work in. Adoption of human factors principles in healthcare has been suggested as a method to improve care delivery and patient safety. In general, the study of human factors encompasses interactions between individuals, the workplace and the tools and equipment used, while considering how they can be optimised to reduce control errors. For example, safety checklists in surgery were developed from human factors principles to address the high rates of avoidable critical events and promote process improvement in the operating room (OR). However, interventions based on human factors can fail without a complementary system or culture that supports these initiatives, especially when they are simply viewed as additional tasks to complete. Accordingly, more work is required to apply human factors principles in system architecture and organisational culture to advance patient safety, provider experience and efficiency.

Human factors have been especially relevant in nuclear science and aviation industries where seemingly insignificant errors can...
lead to critical incidents. One recent example of such errors was the false missile alert in Hawaii that resulted from communication failures between employees, causing widespread panic, multiple emergency dispatch calls and vehicle accidents. In surgery, complex interactions between multiple personnel (eg, surgeons, anesthesiologists, nurses, other perioperative workers), different equipment and tools (eg, surgical devices, monitors) and OR administration (eg, access, staff availability) make it crucial yet challenging to effectively adopt and apply human factors principles to improve patient safety and provider experience. The critical nature of operative procedures adds vulnerability to errors that can constitute up to 79% of adverse events in healthcare. Moreover, the encapsulated setting of the OR, related to sterility and patient privacy, does not lend itself well to external examination. This amplifies the challenge around obtaining robust intraoperative analysis and participation in reflective quality improvement practices. As such, awareness around human factors has been shown to be heterogeneous among frontline surgical providers.

However, this heterogeneity cannot be attributed solely to individual or system resistance to human factors uptake. Intersecting between fields in engineering, psychology, medicine and other numerous disciplines, there is considerable variation and range in how human factors are applied in practice. Ergonomics, for example, is sometimes used interchangeably with human factors with a focus on workplace and product design, while other proponents consider human factors to capture a more psychological or cognitive sphere such as nontechnical skills. Likewise, various theoretical frameworks on the role of human factors in surgery have been described, but how they are being translated to actual practice in the OR and what is collectively being labelled under the concept of human factors in vivo remain unknown.

Effective and meaningful integration of human factors in surgical safety improvement efforts is highly dependent on education and knowledge translation of human factors for healthcare professionals. Currently, the International Ergonomics Association defines human factors as the scientific discipline concerned with the understanding of interactions among humans and other elements of a system. Analyses of flow disruptions in surgery have also demonstrated that factors beyond individual nontechnical skill errors, such as equipment and technology problems as well as issues in resource accessibility and poor systems organisation, can lead to patient safety incidents and a reduced provider experience. But whether human factors in the OR are being used to describe and address such concepts that span the individual, the workplace and the tools used, and whether healthcare professionals are being trained in these areas are unknown.

The objective of this scoping review is to describe human factors for the intraoperative environment as characterised by the content and tools used in human factors education or training for healthcare professionals and trainees who work within or interface with the OR. The findings of this scoping review will demonstrate practical application of human factors and knowledge gaps among healthcare professionals in surgery. This will ultimately inform future human factors’ integration, curriculum development and quality improvement to advance patient safety in the OR.

**METHODS**

A scoping review of the literature will be conducted to investigate the content, application and effect of individual interventions that are labelled as human factor training or education for the OR environment. This study will follow the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews guidelines. Development of this study will be informed by key stakeholders in human factors including a human factors expert (BT), clinicians from the OR (JAK, FB) and a health systems research expert (CK).

**Stage 1: identifying relevant training offerings**

The following electronic bibliographic databases have been searched in August 2020 in consultation with a research librarian who drafted and refined the search strategy with the research team: MEDLINE, Embase, PsycINFO, CINAHL, Health and Psychosocial Instruments and ERIC. These databases were searched from inception to August 2020, and no restrictions were applied. The search strategy combined the term ‘human factors’ with concepts related to ‘training’ (eg, teaching, education, intervention, course etc) and ‘operating room’ (eg, surgery, intraoperative, surgeon, nurse, anesthesiologist etc). The search strategy used for MEDLINE is included in the online supplemental appendix A. Reference lists of included studies will be hand checked to ensure that all relevant literatures have been identified. In addition, a research librarian will provide a list of key articles in human factors in surgery that will be hand checked and screened for inclusion or exclusion.

**Stage 2: study selection**

Titles and abstracts of studies retrieved by the search strategy will be independently screened by two authors who will identify articles that potentially meet the inclusion criteria. Full-text articles of the potentially eligible studies will then be retrieved and independently assessed for eligibility. Any disagreements will be resolved by discussion or input from a third author if disagreement persists. Reasons for excluding studies will be documented. A preliminary search of PROSPERO, MEDLINE and Embase was previously conducted and no systematic or scoping reviews on the topic were identified. The eligibility criteria are described in terms of the population, concept and context as recommended by the guidelines.
Inclusion criteria

- **Population:** clinical (e.g., surgeons, nurses etc) and nonclinical (e.g., OR administrators, housekeeping staff, hospital porter etc) personnel who work in and/or directly interface with the OR.
- **Concept:** any individual education or training intervention that includes teaching labelled under ‘human factors’ for the OR setting.
- **Context:** original research articles published in any year in the English language including single-arm studies, double-arm studies, qualitative and quantitative studies, randomised controlled trials and quasi-experimental studies.

Exclusion criteria

- **Studies** that do not report the content of the human factors training offering.
- **Studies** without a component specific to the OR environment (e.g., surgical ward, emergency department etc).

### Stage 3: data charting

Two authors will independently chart data from the included articles onto a standardised data spreadsheet using Microsoft Excel V.16.46, which will be piloted by the authors with example papers to provide necessary calibration and ensure accuracy. Data will be charted by two authors and any disagreements will be resolved through discussion or with input from a third author when disagreement persists. Charted information will include:

- **Study information:** author(s) information, year of publication, country of origin, article keywords, study type.
- **Training participants:** number, type of and level of training of learner(s) (e.g., surgeons, nurses, residents etc), number and type of teacher(s) (e.g., human

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**Table 1** CIEHF knowledge areas of human factors and ergonomics

<table>
<thead>
<tr>
<th>Anatomy and physiology</th>
<th>Psychology</th>
<th>People and systems</th>
<th>Work environment</th>
<th>Methods and tools</th>
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<tbody>
<tr>
<td>Ageing</td>
<td>Attention</td>
<td>Communication systems</td>
<td>Abnormal environments</td>
<td>Anthropometrics</td>
</tr>
<tr>
<td>Anatomy</td>
<td>Behaviour and attitudes</td>
<td>Human–computer interaction</td>
<td>Auditory environment</td>
<td>Data collection and analysis</td>
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<tr>
<td>Biomechanics</td>
<td>Behavioural safety</td>
<td>Human factors integration</td>
<td>Mechanical environment</td>
<td>Ethics</td>
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<tr>
<td>Disabilities and vulnerabilities</td>
<td>Change management</td>
<td>Human–machine systems</td>
<td>Thermal environment</td>
<td>Evaluation of work activities</td>
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<tr>
<td>Human auditory system</td>
<td>Cognition</td>
<td>Human reliability and error</td>
<td>Visual environment</td>
<td>Experimental design</td>
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<td>Human visual system</td>
<td>Communication</td>
<td>Job design</td>
<td>Workplace design and assessment</td>
<td>Focus groups</td>
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<tr>
<td>Musculoskeletal disorders</td>
<td>Culture</td>
<td>Manual handling</td>
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<td>Knowledge elicitation</td>
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<td>Physiology</td>
<td>Decision-making</td>
<td>Organisational change</td>
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<td>Measurement techniques</td>
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<td>Physiotherapy</td>
<td>Group behaviour</td>
<td>Organisational learning</td>
<td></td>
<td>Questionnaire and interview design</td>
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<td>Repetitive strain injuries</td>
<td>Job satisfaction</td>
<td>Product design</td>
<td></td>
<td>Statistics</td>
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<td>Leadership</td>
<td>Process analysis</td>
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<td>Task analysis</td>
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<td>Learning</td>
<td>Safety culture</td>
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<td>Memory</td>
<td>Shiftwork</td>
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<td>Motivation</td>
<td>Socio-technical systems</td>
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<td>Perception</td>
<td>System engineering</td>
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<td>Psychological stress</td>
<td>Team work</td>
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<td>Psychometrics</td>
<td>User centred design</td>
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<td>Psychophysics</td>
<td>User experience</td>
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<td>Situation awareness</td>
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<td>Supervision</td>
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<td>Training and competence</td>
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<td>Workload</td>
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CIEHF, Chartered Institute of Ergonomics & Human Factors.
factors experts etc), interdisciplinary versus intradisciplinary learning.

- Training design: type of training developers (eg, psychologists, airline pilots etc), type of training mediums or tools used (eg, presentations, simulations, briefing etc), length of training, frequency of training, assessment tool and type used (eg formative, summative, behaviour rating systems etc).
- Training content: learning objectives, skills or concepts taught (eg, communication, situational awareness, ergonomics etc), quantitative or qualitative outcomes measured or described, feedback from participants.
- Training cost.

Stage 4: summarising and reporting results
Collected data will be presented in a tabular or diagrammatic form along with a narrative summary in a manner that aligns with the objectives and scope of this review. Study characteristics including author information, year of publication, location of the research institution and study type will be summarised. Training participants and design, including learner type and number, trainer type and number, training duration and frequency, training format, training assessment and training outcome will also be summarised.

A narrative synthesis of training content will be provided based on the learning objectives and skills or concepts taught in each training offering. Training content will be further summarised by evaluating each study according to the 67 knowledge areas of human factors and ergonomics as described by the Chartered Institute of Ergonomics & Human Factors (CIEHF) (table 1). These knowledge areas represent different components or categories of human factors as defined by CIEHF, some of which may or may not apply to the current adoption and use of the term human factors for the OR setting. For the purpose of this study, the CIEHF framework will be used to characterise human factors for the OR based on the most frequently observed knowledge areas among the included studies. Two authors will be trained by a human factors expert and staff surgeon on the CIEHF framework to classify each training offering under the appropriate knowledge area(s). Inter-rater reliability will be assessed using Cohen’s kappa statistics. A calibration session will be held before to ensure accuracy and reproducibility in classifying knowledge areas. The two authors will also independently record any themes that may not have been captured by the CIEHF framework. These themes along with any disagreements between the two authors when categorising the included studies will be resolved through group discussion and consensus. A quantitative meta-analysis and a formal assessment of methodological quality will not be performed due to the anticipated heterogeneity among the included studies and the review’s focus on defining the current scope of HF training for the operative setting.

Patient and public involvement
No patient or public involvement was included in this study.

ETHICS AND DISSEMINATION
This study does not require research ethics board approval. The study will be completed in June 2021. Findings will be disseminated through presentations at academic conferences and will also be submitted for publication in a peer-reviewed journal. Finally, this scoping review will help identify opportunities and knowledge gaps that can be the focus of future research activity and medical curriculum development.

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Contributors AL and FB conceived the study. AL and FB developed the research question and drafted the protocol. AF, AR, BT, CK, FB, JAK and KD provided advice and edits on the final protocol submission. All authors proof-read and approved the final protocol manuscript.

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Competing interests FB is the Director at Saegis, a subsidiary of the Canadian Medical Protective Association. KD is the Programme Lead at Saegis. BT is the Founder and Managing Director at MedLed Ltd.

Patient consent for publication Not required.

Provenance and peer review Not commissioned; externally peer reviewed.

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REFERENCES
8 Ghaferi AA, Myers CG, Sutcliffe KM. The next wave of hospital innovation to make patients safer. Harv Bus Rev 2016;94.
17 What is ergonomics? Chartered Institute of Ergonomics & Human Factors.
Supplementary Appendix A

MEDLINE Search Strategy:
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1 human factor*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] (7356)
2 Operating Rooms/ (13800)
3 exp Intraoperative Period/ (28079)
4 Intraoperative Care/ (16915)
5 exp Monitoring, Intraoperative/ (19979)
6 exp Specialties, Surgical/ (198693)
7 (operating room* or operating theatre* or operating theater* or operating table*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] (45816)
8 (intraoperative or intra-operative).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] (178632)
9 surg*.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] (3143000)
10 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 (3268944)
11 1 and 10 (758)
12 exp Education/ (806872)
13 exp Learning/ (383825)
14 exp Surgeons/ed [Education] (932)
15 exp Anesthetists/ed [Education] (798)
16 exp Nurses/ed [Education] (8375)
17 exp Nurse Specialists/ed [Education] (3921)
18 exp Nursing Staff/ed [Education] (14446)
19 (train* or educat* or teach* or learn* or intervention? or curricul* or program* or course* or coach* or workshop* or lecture* or class* or lesson* or mentor*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] (5385200)
20 (drill* or exercise* or school* or instruction* or apprentice*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating subheading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] (772976)
21 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 (5972972)
22 11 and 21 (482)