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ESSAY

Human factors and translational simulation: misunderstandings and potential opportunities

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ABSTRACT

There are great synergies between human factors and translational simulation, with both approaches sharing the goal of improving patient care and the working lives of healthcare practitioners. However, a combination of misconceptions about human factors in the simulation community and a limited understanding of the capabilities of simulation within the human factors community means that the great potential for synergies between human factors and translation simulation remains unrealized. The field of human factors offers methods, models and theories to support simulationists to better understand their organizations. Translational simulation offers an ideal vehicle for human factors practitioners to engage in systems analysis and testing. Simulation also serves as a laboratory for research, design and development. Yet such collaborations are still relatively rare. Healthcare simulation is predominantly used for training, and human factors practitioners are largely unaware of the opportunity that simulation offers to support human factors work. We encourage members of both the simulation and human factors communities to build partnerships to the benefit of patients, healthcare workers and the entire healthcare system.

What this essay adds

- It describes the principles and concepts behind human factors and translational simulation and how they are related.
- It outlines common misunderstandings and misconceptions about human factors and translational simulation.
- It provides suggestions and examples of how human factors approaches can be applied to translational simulation.
- It makes recommendations for how to encourage collaboration between human factors and translational simulation practitioners.

Introduction

There are great synergies between human factors and translational simulation. Both disciplines share the goal of improving performance, safety and efficiency of health care, both are concerned with interactions and interfaces within complex systems, and both rely on the involvement and contribution of healthcare practitioners and other stakeholders. Yet, evidence suggests that human factors are not well integrated into health care [1]. It has been suggested previously that

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translational simulation will be enhanced if it 'joins the conversation' with quality improvement practitioners [2]. In this essay, we would like to suggest that translational simulation activities could be further enhanced by 'joining the conversation' with human factors practitioners to realize the significant, yet largely untapped, synergies between human factors and translation simulation. In this essay, we will: (i) outline the principles, concepts, and misconceptions about human factors and translational simulation; (ii) explore how human factors approaches can support translational simulation; and (iii) make recommendations to encourage collaboration between human factors and translational simulation practitioners.

Human factors

Human factors principles and concepts

Human factors has been defined as 'the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance' [3]. Human factors is also often used interchangeably or in combination with the related term 'ergonomics'. Human factors seeks to first understand, and then to design work processes and systems to support human performance and patient safety. Dul et al. [4] identify three characteristics of human factors: (i) it takes a systems approach; (ii) it is design driven; and (iii) it focuses on performance and well-being outcomes. However, misconceptions about human factors have limited the application of this discipline in simulation as well as health care more generally [1].

Misconceptions about human factors

A particular misconception about human factors is that it is often equated with or used as a synonym for human error [5]. This is the exact opposite of the goal of human factors, which seeks to create system resilience rather than to prevent human error. Focusing on errors is a reactive stance. It detracts from the true goal of human factors, which is to understand the system and anticipate risk and failure before it happens. An error focus fails to recognize the myriad of ways that healthcare workers prevent or mitigate the problems that occur in an imperfect system. Misattributing adverse events to the errors of front-line workers also perpetuates a culture of blame, which encourages workers to cover up their mistakes. Clearly, such misattributions hinder both learning and improvement. Healthcare providers often feel personally responsible for errors; they fail to fully recognize the contribution of latent threats within the system, to adverse events [6]. Simulation is an ideal mechanism for a proactive examination of the system from a human factors perspective. However, if the contribution of human factors is overlooked, utilizing simulation for this purpose will remain unexploited.

Another common misconception is that human factors have become synonymous with 'non-technical skills'. 'Non-technical skills' can be defined as the social (teamwork, leadership and communication), cognitive (situation awareness and decision-making) and personal resource skills (managing stress and fatigue) underpinning effective team performance [7]. Although 'non-technical' skills are broadly accepted as a term within human factors, there has been some criticism of this collective noun in the simulation literature (e.g. the term relies on the identification as something it is 'not') [8]. A suggestion to aid clarity around the term is to be more specific and identify the particular non-technical skill (e.g. decision-making) or group of skills (e.g. cognitive skills) identified [9].

For many healthcare practitioners (including managers), their first and perhaps only engagement with human factors has been through the medium of these non-technical skills or team training. Such training is often described as 'human factors training' [10], despite the fact that its scope is usually limited to social and cognitive skills. While these skills are addressed within human factors, they are only one specific component of this discipline. The delivery of safe, efficient and effective health care relies on more than the knowledge and skills of individuals and teams. Delivery is also dependent upon systems, processes and environments that support the work of individuals and teams [11].

Simulationists often use the taxonomies and frameworks developed by human factors specialists to support the training and assessment of 'non-technical skills' (e.g. the Anaesthetists' Non-Technical Skills system [12]). A fundamental principle of human factors is that systems should be designed to support people rather than using training or rules to compensate for poor system design. Simulation can be a vehicle for exploring the interaction between people and system elements. It can illuminate the interfaces and the complexity within systems. Human factors theories, models and approaches can then help to make sense of the findings [11].

Translational simulation

Translational simulation principles and concepts

Translational simulation is a simulation that is designed to *directly* improve patient care and healthcare systems [13]. The word 'translational' is deliberate. It draws attention to the goal of directly impacting healthcare delivery, rather than having an indirect impact through training [2]. Baxendale et al. [14] identify four purposes of translational simulation: (i) to understand events; (ii) to design and test; (iii) to practice; and (iv) to assess and evaluate.

While it is important to maintain a focus on the purpose of translational simulation, the field lacks a clear conceptual frame to guide the *process* of translational simulation [15].

Nickson et al. [13] recommend utilizing a phased approach. They propose an input–process–output framework to guide the process. This framework is helpful because it emphasizes that an analysis phase precedes the intervention phase and that outputs are cyclical. The analysis phase is critical as this is where the problem is diagnosed and the appropriate approach to tackle it is designed. The knowledge that is developed from the analysis phase forms the basis for functional task alignment between the purpose of the translational simulation and the design of the simulation to achieve these goals. This approach is a clear departure from those used in simulation-based education, where the simulation is designed to meet predefined learning outcomes and objectives, and the debrief is focused on the performance of those participating in the simulation. In contrast, translational simulation is not guided by learning outcomes and objectives; the objectives are emergent. The focus is on understanding how the whole system functions, not just the performance of the healthcare workers.

Misconceptions about translational simulation

Until recently, there has been a strong focus in published simulation research on education. To illustrate, a bibliometric review of the 100 most cited papers in simulation found that the majority (86%) of studies were concerned with education or training [16]. Although this is beginning to change, there is a lack of awareness or understanding of the potential for simulation to be used as a tool for system improvement. This lack of awareness may be due to a lack of knowledge by clinicians and organizational change makers on the theories, models and approaches for understanding sociotechnical systems. It could also be due to the fact that conventional pedagogical models, such as experiential learning theory, deliberate practice or mastery learning, are insufficient to meet the objectives of translational simulation. Simulationists must embrace new theories and models to support their understanding of a translational simulation approach.

Applying human factors approaches to translational simulation

Human factors practitioners have struggled to apply their expertise in order to bring about meaningful clinical benefit [11]. Translational simulation offers a mechanism for human factors practitioners to use simulation for systems analysis and improvement. In turn, translational simulation can benefit from the theories, models, frameworks, and approaches and methodologies from the discipline of human factors. Simulation-based education is based upon learning outcomes and objectives, with the debriefing focused on the behaviours of those participating in the simulation. In contrast, translational simulation is focused on understanding the system – this necessitates a different approach to debriefing. This may require human factors practitioners to identify frameworks and approaches to support a translational simulation debriefing – and the subsequent learning and recommendations derived from the translation simulation activity. In the examples below, human factors methods, tools and approaches are utilized in conjunction with translational simulation to explore, design and improve healthcare facilities and services.

Device design

The most commonly used international standard for human factors engineering and usability risk management of medical devices is IEC 62366 [17]. This standard complies with usability regulatory requirements in the European Union, the United States and many other countries. However, whether these devices are usable in the actual clinical environment is often overlooked during development and in the mandatory regulatory processes. It has been argued that the device testing that is done may not reflect the 'messiness' of clinical practice [18]. Usability testing in context can be explored using simulation to replicate various routine as well as high acuity low occurrence events, to consider the adequacy, usability and practicality of devices before they are procured by the health service.

Procedural guidelines

Simulation can be used in conjunction with a human factors approach known as human reliability analysis (HRA). HRA consists of a range of techniques that can be used to examine reliability and variability in the performance of clinical tasks or procedures, which may involve the use of a device or technology [19]. HRAs are common in other high-risk industries, but much less so in health care [20]. The goal of HRA is to understand critical tasks and potential errors and to develop procedural guidelines for task performance. Examples of HRA applied to critical care and surgical tasks include: preparing and delivering anaesthesia [21]; endotracheal suctioning [20]; ultrasound-guided right internal jugular vein cannulation [20]; rapid-sequence intubation [20]; functional endoscopic sinus surgery [22]; bronchoscope-assisted percutaneous dilatational tracheostomy [23] and intercostal chest drain insertion [24]. Simulation can support HRA in two ways. Simulation provides a safe and controlled environment for steps in a procedure to be examined, from which procedural guidelines can be developed. It also provides a safe environment to test the integration of devices and procedural guidelines before they are used in the real clinical environment.

Facility design

Human factors principles from ergonomics and anthropometrics can be utilized within a simulation setting to support the design or redesign of healthcare facilities to ensure they meet the needs of staff and patients. For example, simulation was used to evaluate potential patient and staff safety risks associated with a connector passageway between two hospital buildings [25]. An interprofessional team of intensive care clinicians participated in two simulations to evaluate the implications of the new connector passageway on patient movement. A failure mode and effects analysis and debrief were used to evaluate risks and potential failures. Based on the analysis, a decision was reached to invest $9.85 million in a new connector link corridor [25].

System design

Human factors approaches can be used to support simulations of systems-level issues. Sometimes these are *in silico* simulations that utilize computer-based models to simulate the clinical environment. For example, *in silico* simulation using computer-based modelling has been used to address waiting times [26] and other aspects of workflow through a healthcare unit or hospital [27]. Human factors tools, such as the NASA Task Load Index, can be used to examine the workload of healthcare team members in a simulated setting. For example, in an assessment of the relationship between workload and task performance in a simulated laparoscopic surgery, it was found that increased workload was associated with poor task performance and a higher likelihood of errors [28]. *In situ* simulation could also be used to test healthcare systems under different stress conditions for the likelihood of error. These evaluations will provide evidence to support improvements to system design.

Adverse event investigation

Simulation can support a Safety I approach (i.e. learning from when things go wrong) to adverse event investigation by allowing the identification of contributory factors following an adverse event [29]. It is commonplace in the aviation industry 'to re-fly' accidents in a simulator as part of the investigation [30]. The analysis should utilize an appropriate human factors model of incident causation, such as the Yorkshire Contributory Factors Framework [31] or the Systems Engineering Initiative for Patient Safety model [32]. The focus of the simulation should be on identifying the latent failures within the system, rather than taking a person-focused view. To illustrate, recognizing the limitations of root cause analysis, Langevin et al. [33] developed a simulation-based event analysis approach, and used it to analyse two paediatric adverse events. If this approach is to be taken, then it is recommended that the participants are not the actual healthcare providers involved in the adverse event to avoid causing further emotional distress.

Systems probing

The same human factors models used to support adverse event investigation can also support the use of simulation to proactively evaluate normal work practices and identify the hidden or latent patient safety threats within a system. This use is consistent with a Safety II approach (i.e. learning from when things go right) [29]. The use of simulation in this way is called 'systems probing' [34]. Although not yet prevalent in health care, the use of simulation for systems probing is commonplace in other industries as an approach to proactively identify and manage risk, and there are some examples reported in the healthcare simulation literature. For example, a systems probing study developed by simulation, human factors and patient safety experts was carried out to identify systems issues related to a hospital transfusion policy. Data on active and latent factors that contributed to the adverse event were collected using translational simulation and a Failure Modes and Affects Analysis. Contributing factors identified included a lack of clarity on critical steps of the blood transfusion process, a lack of standardized guidelines relating to prescribing medications for prevention of potential transfusion reactions, and interruptions and distractions [35]. Based upon the findings, recommendations were provided to the participating units on the physical space, policy and procedure redesign.

Recommendations for fostering collaboration

Recommendations for human factors practitioners

We recommend that human factors practitioners working in health care should familiarize themselves with healthcare simulation and learn how simulation can potentially be integrated into their work. We suggest that human factors practitioners visit a simulation facility, or service, to observe and learn about simulation. The Society for Simulation in Healthcare has an open-access worldwide directory of over 1,000 registered simulation centres. We also recommend human factors practitioners read simulation journals, and attend some simulation meetings. Many simulation societies have forums that are particularly relevant for human factors practitioners. For example, the Association for Simulated Practice in Healthcare has a special interest group on human factors. Finally, there is a growing number of postgraduate degrees in healthcare human factors. This reflects a recognition of the role for human factors in patient safety and healthcare system performance. These programmes typically cover theoretical concepts such as safety science, error analysis, system thinking and research methods. There is a need for human factors practitioners to support the practical application of these concepts. Translational simulation can bridge the gap between theory and practice and should be an essential topic that is integrated into these courses.

Recommendations for simulationists

Most healthcare simulationists have received no formal training in human factors. Although simulationists may understand what is required for effective performance, they often lack the language, frameworks or models needed to discuss this during a debrief [36]. In agreement with the recently published global consensus on simulated practice in health care [37], we advocate for prioritizing interprofessional education and team training. We recommend that, at a minimum, simulation facilitators must have a solid grounding in the theories and models underpinning the skills required for effective team performance in order for them to be comfortable and competent in debriefing. However, those engaging, or wishing to engage, in translational simulation will need a deeper level of human factors knowledge and understanding. Simulationists carrying out translational simulation will require additional knowledge of systems theory and models and approaches that support the identification and understanding of issues in the healthcare system.

Similar to what we have recommended for human factors practitioners, we suggest that simulationists interested in translational simulation reach out to human factors practitioners and invite them to their simulations and facilities, read articles in relevant human factors journals (e.g. *Human Factors in Healthcare*), and attend some relevant conferences (e.g. *Conferences for Healthcare Ergonomics and Patient Safety*, *International Symposium on Human Factors and Ergonomics in Health Care*) to look for collaborative opportunities. We certainly encourage healthcare providers to take an interest in human factors. However, a rigorous approach will require human factors practitioners with specialized training and expertise [38].

Conclusion

There are great synergies between human factors and translational simulation, with both approaches sharing the goal of improving patient care and the working lives of healthcare practitioners. However, misconceptions about human factors within the simulation community and a limited understanding of the potential for healthcare simulation for systems analysis by the human factors community impede the realization of this shared goal. We encourage members of both the simulation and human factors communities to build partnerships for the benefit of patients, healthcare workers and the healthcare system.

Declarations

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Competing interests

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