Integration of human factors/ergonomics in healthcare systems: A giant leap in safety as a key strategy during Covid-19

Yordán Rodríguez | Sue Hignett

1National School of Public Health, Universidad de Antioquia, Medellín, Colombia
2School of Design & Creative Arts, Loughborough University, UK

Abstract

In this article, we present a model for integrating Human Factors/Ergonomics (HFE) into healthcare systems to make them more robust and resilient. We believe that to increase the impact of HFE during and after the Covid-19 pandemic this integration should be carried out simultaneously at all levels (micro, meso, and macro) of the healthcare system. This new model recognizes the interrelationship between HFE and other system characteristics such as capacity, coverage, robustness, integrity, and resilience. We hope that the model will serve as a reference for a giant leap to design and improve the safety and effectiveness of healthcare services from a holistic (systems) perspective.

KEYWORDS

healthcare, human factors integration, patient safety, resilience, systems ergonomics

1 | INTRODUCTION

Healthcare systems are defined by World Health Organization (WHO) as: “all organizations, people and actions whose primary intent is to promote, restore or maintain health. This includes efforts to influence determinants of health as well as more direct health-improving activities” (WHO, 2007; page 2). Today, strengthening healthcare systems has become a major challenge, due to the huge pressure that the Covid-19 pandemic has imposed. In response, the discipline of Human Factors/Ergonomics (HFE) can contribute to improving safety, communication between work teams, guidance to the community, risk management, aspects of organizational culture, design of personal protective equipment (PPE), workload, among others (Gurses et al., 2020; Hignett et al., 2013; Hignett et al., 2021). In this article, we present a model for integrating HFE into healthcare systems to make them more robust, and thus improve safety and effectiveness.

Since WHO declared Covid-19 a pandemic on March 11, 2020, an alert was automatically issued to all healthcare systems to prepare and take action to increase service capacity. However, despite remarkable efforts, the reality is that no countries were prepared for a pandemic of such magnitude. As of April 21, 2021, globally, there are more than 140 million reported cases of COVID-19 and 3 million deaths. This situation has tested even the more mature/established health systems, for example, Spain, Italy (Legido-Quigley et al., 2020; Remuzzi & Remuzzi, 2020). As a result, many institutions and professionals have begun a crusade to seek solutions to confront this global health crisis, for example the development of an effective vaccine (Kirby, 2020; WHO, 2020a). Meanwhile healthcare systems have to cope with the additional Covid-19 burden whilst trying to return to previous service capacity and plan for seasonal (flu) infections.

A central component of healthcare systems is the employees; they are the fuel that sustains and keeps the whole system in motion. However, the lack of health personnel is one of the main challenges facing many healthcare systems, mainly in low, and lower-middle income countries which have to increase their total health workforce in 42% and 25%, respectively, to attain the targets of the Sustainable Development Goals in 2030 (WHO, 2016). This situation has been aggravated by the number of health professionals infected with Covid-19. For example, it is reported that front-line health workers in the United States and United Kingdom are at greater risk of infection than the general community (adjusted hazard ratio: 3–40;
95% confidence interval: 3-37-3-43), due to the lack of availability, reuse and inadequacy of PPE (Nguyen et al., 2020). This poses a major challenge at the global level, with the focus of increasing the safety of patients, their families and healthcare personnel, whilst improving the robustness, resilience, and effectiveness of healthcare systems.

Safety in healthcare systems has foundered over the last 20 years since the seminal publications on the higher level of iatrogenic harm (Department of Health, 2000; Kohn et al., 2000) where it was reported that at least 10% of patient admissions could result in some form of harm.

Wears and Sutcliffe (2020; page 5) describe healthcare (patient) safety as a "movement becalmed ... [or]... dead as a reform effort." They suggest that the "patient safety movement itself has gotten things wrong. Its understandings ... of concepts such as safety, harm, risks and hazards are incomplete and simplistic and, as a result, its work has been grounded in assumptions and generalisations that are either wrong or lacking in context."

"Sociologists, psychologists and engineers have asserted that the narrow focus on preventing things from going wrong, as opposed to understanding and enhancing the ability to make them go right is fundamentally limiting for improving safety." They identify three separate patient safety narratives which briefly aligned in 1991 but lost momentum into three disparate narratives. We suggest that this new model offers an opportunity to unite these narratives:

1. Medical and health-science community; came from a desire to mitigate malpractice claims; grounded in epidemiology and generally takes the form or research reports;
2. Safety sciences (including HFE, social sciences, engineering, psychology) concerned with safety in a variety of high-risk activities;
3. Popular media—small influential group of dramatic and poignant accounts of medical harm, tragic personal stories of innocents injured.

We suggest that the COVID-19 pandemic offers an opportunity for a step change (giant leap) in the integration of HFE in healthcare which should be shared via local HFE communities to healthcare providers.

2 | MODEL OF INTEGRATION OF ERGONOMICS IN HEALTHCARE SYSTEMS

We propose that our Model for the Integration of Ergonomics in Healthcare Systems (MIEHS, Figure 1) can be used to improve patient and healthcare worker safety by integrating the above three narratives to achieve more robust and effective healthcare systems.

MIEHS uses the societal protective function that healthcare systems act as a "protective wall," to protect society (e.g., cities, communities) from the threats from Covid-19. The blocks in the wall represent the components of the healthcare systems with which human beings interact, for example, at the micro level for PPE, at the meso level with a multidisciplinary working group and at the macro level between institutions, communities, health systems of the countries.

MIEHS is scalable, which means that it can be used to represent the interactions that occur in one area/process of a hospital, among all areas of a hospital, among the different healthcare institutions in a region, among the different actors and services that make up the healthcare system in a country, or even at the global level.

The model is based on two approaches: (1) the socio-technical systems approach to represent the interactions between human beings and the other elements of the health system (Carayon, 2006; Wilson, 2014), and (2) the Systems of Systems (SoS) approach to represent/analyze the interactions that occur at the macro level (between the systems that make up health systems), where the complexity of the system is greater (Siemieniuch & Sinclair, 2014; Wilson, 2014).

Five specific interrelated characteristics/properties of healthcare systems are represented:

- **System capacity** is represented by the height of the wall—more height indicates a greater system capacity (Figure 1). Healthcare systems in several countries have focused their efforts exclusively on increasing capacity: construction of new hospitals (in China and United Kingdom), fitting out more intensive care rooms, purchase of respiratory ventilators, purchase of PPE, increase in the recruitment of healthcare personnel, etc.; although these are all important, efforts should also be directed at improving other properties of the healthcare systems (e.g., robustness).
- **Robustness** is the effectiveness of the interactions between the elements of the system, with an emphasis on those with and
between the human component (e.g., safety glasses, surgical masks, teamwork and coordination through transitions of care, gloves, risk communication, etc.). It is represented in Figure 1 by the joints between blocks and is where the application of HFE has the greatest potential. The lack of or inadequate application of HFE principles can create holes in the wall (healthcare system), for example as error opportunities facilitating the passage of COVID-19 with undesirable results (infected people, deaths, medication errors, damage to the patient, accidents at work, health problems in health personnel, etc.).

- **Coverage** is related to: “access to a broadening range of benefits, for all citizens without exclusion, and with the necessary social protection. Depending on the context, the accent may be primarily on broadening the package; or on extending coverage in excluded groups; or on improving social protection” (WHO, 2007; page 4). In our model, this property is represented by the wall length (Figure 1), and is influenced by governmental, socioeconomic, cultural, historical, geographical, political factors, etc.

- **Integrity** represents the complex connections between the blocks of the wall, which are needed to understand the healthcare system as a whole (Figure 1). This addresses the medical and health-science community narrative by showing the connection between the components and emphasizing that the overall result does not depend on the isolated components.

- **Resilience** can be defined as: “a feature of some systems that allows them to respond to an unanticipated disturbance that can lead to failure and then to resume normal operations quickly and with a minimum decrement in their performance” (Fairbanks et al., 2014). Resilience is a scalable property that can be found in systems of different sizes, although this is most evident in dramatic large-scale events (Fairbanks et al., 2014), such as the Covid-19 pandemic. Healthcare systems make constant adjustments that allow them to respond to different situations and demands. These adjustments change the interactions between humans and the other components of the system (Wears et al., 2015). In our model, resilience is represented in Figure 1 by the various forms and connections that the components (blocks) of the healthcare system (wall) adopt to cope with complexity, constant change, and unexpected work situations (Iflaifel et al., 2020).

In the MIEHS model, the five properties described should be analyzed for each level (micro, meso, and macro). For example, a key question would be: How to improve the (capacity, robustness, coverage, integrity, resilience) of the system under study by integrating HFE at the micro, meso and macro levels?

The MIEHS model does not create a hierarchy for the possible interactions between humans and the other components of the system (organizational, tools, building design, personal protective equipment, etc.). As shown in Figure 1, any failure in the human-system interaction can cause an undesirable outcome, for example, represented as the passage of a coronavirus.

There are several properties of healthcare systems that must be addressed; however, it must be emphasized that the fundamental focus of MIEHS is to improve the robustness of the healthcare system which is not only important at the critical moments of the Covid-19 pandemic, but also under normal conditions. For example, high-capacity healthcare systems may have undesirable outcomes, because even if the system burden from the Covid-19 pandemic does not exceed capacity (the coronavirus does not pass over the wall), undesirable outcomes may still occur because interactions between components at the lowest levels of the health system (wall) may fail, creating holes that cause these undesirable outcomes (the coronavirus passes through the holes in the wall). This shows the need to increase the capacity and robustness of the healthcare system in parallel. This has been seen with increasing waiting lists for cancer treatment, surgical procedures, diagnostic investigations etc. Improving the robustness of the healthcare system would support continuation of services, whilst also adapting capacity to respond to the demands associated with the pandemic.

Several models have previously been proposed to analyze and improve patient safety from a systems perspective. Two well-known models are the Swiss Cheese model, developed by Reason (Reason, 2000), which was later adapted to patient safety in the healthcare sector (Vincent, 2010); and the Systems Engineering Initiative for Patient Safety (SEIPS) model (Carayon et al., 2006), which has been refined since its initial publication SEIPS 2.0 (Holden et al., 2013) and SEIPS 3.0 (Carayon et al., 2020).

These previous models have been very useful in the improvement of healthcare systems. However, we consider that with our model (MIEHS or Protective Wall), offers additional aspects. Table 1 shows a comparison between the Swiss Cheese, SEIPS, and MIEHS models.

First, MIEHS highlights the importance and need to integrate HFE to strengthen the barriers developed in healthcare systems to improve safety. HFE can help to optimize the interactions between the human component and the other components (engineering, organizational, human) of the barriers (Hignett et al., 2018). For example, in the Swiss Cheese model, it is pointed out that there are weaknesses in the barriers (holes in the pieces of Swiss Cheese) that, when aligned, can result in an accident or the occurrence of an adverse event. We believe that MIEHS can be used to identify, eliminate or diminish the magnitude of the existing weaknesses (holes) in the barriers at the different levels of the system (individual, teams, organizational, interorganizational), and therefore, contribute to the strengthening of the existing barriers and the robustness of the system.

Second, MIEHS emphasizes the importance of analyzing the interactions or connections beyond the boundaries of the healthcare system at the organizational level. This means that interactions must be analyzed from the micro-level (a person using a tool) to the macro-level (interorganizational at the local, regional, or global levels). In this way, the benefits from the SoS approach are incorporated. In the SEIPS and Reason/Vincent models, the scope is limited to the organizational level (e.g., hospital). For the SEIPS model, the influence of other factors and interactions that occur beyond the organization (external environment) are recognized.
However, SEIPS does not emphasize these interactions (inter-organizational systems interactions, systems community interactions), which have been shown to be important in the Covid-19 pandemic. For example, the WHO called attention to the need to increase the production of PPE globally due to shortages caused by the pandemic (WHO, 2020c). WHO has also issued a set of recommendations to support and develop risk communication and community engagement plans that enable effective communication with the public, engaging with communities, local partners and other stakeholders to help prepare and protect individuals, families and the public’s health during the early response to COVID-19 (WHO, 2020b).

Thirdly, MIEHS recognizes how the integration of HFE can impact on the general properties of healthcare systems (robustness, capacity, coverage, resilience, integrity), directly and indirectly. These properties are related to each other and have a significant influence on the general performance of healthcare systems, and therefore we believe it is beneficial to analyze them from the HFE perspective.

3 | ROAD MAP FOR APPLYING THE PROTECTIVE WALL MODEL (MIEHS)

In this section, we propose a set of actions grouped into four phases that we believe would contribute to the implementation of the proposed model. We suggest that the development of these phases occur simultaneously and over a 10-year time horizon, which is aligned with the recent global patient safety action plan proposed by WHO (WHO, 2021) and informed by the road map for integrating HFE into UK healthcare systems (Hignett et al., 2017).

**Phase 1. Awareness raising (1–3 years):** the goal in this phase is to raise awareness of the importance and impact of integrating HFE into healthcare systems using the proposed model. This can be achieved by organising congresses, workshops, webinars, and conferences with the support of local and national (e.g., HFE societies and universities) and international (e.g., WHO and International Ergonomics Association) organisations. Actions in this phase would be aligned with the recent WHO global patient safety action plan, which proposes: “an action-oriented framework to facilitate the implementation of strategic patient safety interventions at all levels of healthcare systems globally over the next 10 years (2021-2030)” (WHO, 2021).

**Phase 2. Education (3–10 years):** the goal to be achieved in this phase is to educate HFE professionals in healthcare to contribute to the implementation of the proposed model. The need for more ergonomists to integrate HFE into healthcare systems is a topic of interest in both industrially developing countries (Aceves-González et al., 2021) and industrially advanced countries (Hignett & Bowie, 2020).

The inclusion of HFE issues in the curricula of healthcare professionals is not new. For example, in 2011 WHO proposed the Patient Safety Curriculum Guide for training of healthcare professionals (World Health Organization & WHO Patient Safety, 2011),
where 2 of the 11 proposed topics are related to HFE: Topic 2: Why applying human factors is important for patient safety; and Topic 3: Understanding systems and the effect of complexity on patient care. However, there are currently few HFE programmes with a focus on healthcare, and new programmes need to be developed.

Although educational actions will be permeated by their context (Aceves-González et al., 2021), we suggest that the hierarchical five-level approach to professionalise patient safety (using HFE) proposed for UK can serve as a reference (Hignett & Bowie, 2020):

- **Level 1. Awareness.** Patient Safety including HFE and Quality Improvement (1 h online e-learning).
- **Level 2. Understands.** Patient Safety Syllabus and Chartered Institute of Ergonomics and Human Factors (CIEHF) competencies. Linked to clinical professional development (60 h via 1 day courses).
- **Level 3. Demonstrates.** Patient Safety (Technical CIEHF) Specialist. Mentored route via experiential learning and/or PGCert (600 h).
- **Level 4. Integrates (organizational role).** Qualified Safety Scientist (e.g., Chartered Ergonomist). Recognized qualification (MSc) and professional indemnity insurance.
- **Level 5. Leads (national role).** Expert Qualified Safety Scientist with PhD and more than 10 years experience.

**Phase 3. Methods and tools** (3–5 years): the goal in this phase is to conform a toolkit to implement the proposed model. This can be done using the various HFE methods/tools available (Stanton et al., 2005; Wilson & Sharples, 2015). The use of methods will depend on the purpose and level of training and experience of the staff using them (Hignett & Bowie, 2020).

We also consider that there is a need to create new methods and tools, which integrate not only knowledge, theories, and approaches from the HFE discipline but also from other disciplines (e.g., public health, medicine, nursing, management, epidemiology, quality improvement, etc.). In this sense, the newly developed tools should be articulated with the five characteristics of healthcare systems stated in the model.

To increase the acceptance and use of the new methods, they should be co-developed with the joint participation of ergonomists and healthcare systems professionals and use familiar terminology for healthcare systems. Finally, we believe that the use of information technologies (e.g., software, technology platforms) would help in the standardisation, usability, and dissemination of these new methods.

**Phase 4. Implementation** (5–10 years): the goal in this phase is to achieve applications of the model in real contexts. We plan applications in Latin American countries (e.g., Colombia and Mexico) driven by the National School of Public Health, Universidad de Antioquia, Colombia, and the Centro de Investigaciones en Ergonomía, Universidad de Guadalajara, Mexico with the support of the Latin America Network of HFE in Healthcare Systems (RELAESA). We are also planning applications in the UK with leadership from the School of Design & Creative Arts, Loughborough University, UK. This would allow the experiences gained in different contexts to be compared to strengthen and refine the model. We hope that other institutions from different countries will join this initiative.

As the proposed actions are being progressively accomplished, ergonomics practitioners can start to use the model as:

1. A means of communication to explain and support healthcare system actors on how HFE integration can help improve relevant properties of healthcare systems (capacity, coverage, integrity, resilience, robustness). In addition, it could help with the understanding and integration of complex concepts that are not commonly addressed in a systematic way.
2. A tool to identify and provide guidance on which aspects of HFE should be considered at the micro, meso and macro levels in healthcare systems, and the relationships between the different levels. This can be done through workshops and focus groups with the support of qualified/experienced ergonomists and the participation of stakeholders.

Overall, we hope that the proposed model will serve as a framework for ergonomics practitioners to move towards a true integration of HFE into healthcare systems in the coming decades to make them more robust and resilient and thus better prepared to face future threats (e.g., new pandemics).

4 | CONCLUSION

We hope that the “protective wall” or MEH model will serve as a reference for decision-makers making a giant leap to design and improve the safety and effectiveness of healthcare services from a holistic (systems) perspective. It provides a visualisation that communicates complex concepts to a range of different audiences. We hope that it will be used to stimulate discussion by integrating the three narratives and professionalising the practice of safety in healthcare.

To increase the healthcare systems’ capacity, it is not enough to just increase funding and resources. It is crucial to have a systems vision, focused on optimizing the interactions between people (health professionals, patients, and their families) and the other elements that make up healthcare systems; this is consistent with the vision promoted by HFE. In this way, better results will be achieved in terms of safety, health, well-being, and improved system performance.

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**PEER REVIEW**

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DATA AVAILABILITY STATEMENT
Data sharing not applicable—no new data generated, or the article describes entirely theoretical research.

ORCID
Yordán Rodríguez http://orcid.org/0000-0002-0079-4336
Sue Hignett https://orcid.org/0000-0002-3025-7451

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