



PERSPECTIVE

HEALTHCARE SYSTEM

## Integrating Human Factors in the Healthcare System: Embracing Aviation Methodologies and Artificial Intelligence (AI) to Enhance Provider Performance and Patient Safety

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### ABSTRACT

Human factors science, which incorporates psychology, engineering, design, and statistics, aims to improve safety and efficiency in healthcare by optimizing the interaction between providers and their systems. This approach is critical in complex medical environments where errors often result from systemic issues rather than individual negligence. Historically rooted in aviation, human factors principles have significantly enhanced safety and performance, offering valuable insights for healthcare. Human factors specialists aim to reduce errors and improve patient outcomes by addressing poorly designed interfaces, inefficient workflows, and inadequate communication systems. The integration of artificial intelligence (AI) into healthcare can further enhance these efforts by predicting patient risks, optimizing treatment plans, and automating routine tasks. AI, designed with human factors in mind, can augment healthcare providers' capabilities, ensuring safety and efficiency. The future of healthcare lies in the seamless integration of human factors and AI, fostering a system that enhances provider performance and patient safety. Learning from aviation's success in minimizing human error through human factors engineering, healthcare can achieve similar safety standards, ensuring a technologically advanced, safe, and human-centered healthcare system.

**Keywords:** Human Factors, Healthcare, Patient Safety, AI, Medical Errors, System Design, Workflow Optimization

### INTRODUCTION

The science of human factors is a multidisciplinary field that combines knowledge and methods from various disciplines such as psychology, engineering, design, and statistics to ensure safety and enhance human and system performance. In healthcare, human factors aim to improve the interactions between healthcare providers and the systems, tools, and processes they use.<sup>[1]</sup> Simply put, human factors research is a scientific approach that focuses on designing systems conducive to human abilities and promoting safety, efficiency, and ease of use. These are critical in healthcare settings, where the cost of errors can be extraordinarily high.

The importance of human factors in healthcare cannot be overstated. With medical environments becoming increasingly complex, the risk of errors that can adversely affect patient outcomes escalates. These errors often stem not from individual negligence but from systemic issues

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like poorly designed interfaces, inefficient workflows, and inadequate communication systems.<sup>[2]</sup> By understanding and developing these elements to better fit human capabilities, human factors specialists aim to reduce errors and improve healthcare delivery.

The focus on human–system interactions is vital because every element of healthcare—from the design of medical instruments to the layout of hospital rooms, from the computer systems that track patient care to the protocols for emergency response—needs to support healthcare providers’ ability to perform their tasks under high pressure and with precision. The ultimate goal of integrating human factors into healthcare is to create a seamless environment where technology and processes enhance healthcare teams’ natural abilities rather than obstruct them. This integration is crucial not only for improving patient care but also for advancing the health system’s resilience and response capacity in both everyday tasks and in times of crisis.

By exploring these interactions and integrating human-centered designs, healthcare systems can significantly enhance the quality of care, reduce medical errors, and ensure a safer environment for patients and healthcare providers. This commitment to understanding and optimizing human factors in healthcare settings not only improves operational efficiency but also holds the potential to transform patient outcomes globally.

### ***History of Human Factors Research***

Historically, the field of human factors expanded significantly during World War II, which saw a push toward designing military equipment that could be operated more effectively and safely. The roots of human factors research are deeply embedded in the aviation industry. The field burgeoned during World War II when the complexity of military aircraft systems increased, necessitating a better understanding of pilot capabilities and limitations. It was quickly recognized that many aircraft accidents were caused by human error stemming from poorly designed controls and operations. This insight led to more intuitive interfaces and interactions in the cockpit to enhance pilot performance and reduce mishaps.

After the war, these principles were quickly adopted in other high-stakes areas. One of them is aviation—a field that has pioneered in applying human factors toward achieving remarkable safety records. The lessons learned from aviation have profound implications for healthcare, suggesting that similar improvements in safety and performance are possible with the thoughtful application of human factors principles.

Aviation’s systematic approach to human factors has made it one of the safest modes of transportation.<sup>[3]</sup> This discipline’s

evolution in aviation provides valuable lessons for other high-stakes domains, including healthcare, where the complexity and risk are comparable.

### ***Human Factors, Medical Errors, and Patient Safety***

In healthcare, the stakes are exceptionally high, with the quality of human–system interactions directly impacting patient outcomes. Integrating human factors in healthcare aims to create safer, more efficient systems supporting providers’ ability to deliver optimal care. This includes the design of medical devices, ergonomics of workstations, patient handling procedures, and workflow organization to reduce fatigue and enhance performance.

Medical errors stand as one of the significant causes of mortality globally, and an alarming number of these incidents are preventable. In healthcare, where the consequences of mistakes can be life-altering, understanding and addressing the root causes of these errors is critical. Most medical errors do not result from individual negligence but rather from systemic issues that can be traced back to poorly designed systems, complex interfaces, and inadequate organizational structures that fail to support the healthcare providers’ operational realities.<sup>[4]</sup>

By incorporating human factors principles into healthcare, professionals can better align the design of equipment, workflows, and environments with the capabilities and limitations of human operators. For instance, the complexity of modern medical devices often contributes to user errors. Simplifying these interfaces can make them more intuitive, significantly reducing the risk of a dangerous mistake. Similarly, the physical layout of a hospital or clinic can influence the efficiency of care delivery and the potential for errors in patient management. Optimizing these spaces for better workflow can lead to safer and more effective patient care.

Moreover, human factors also delve into healthcare delivery’s cognitive and psychological aspects. Healthcare providers often work under intense pressure and fatigue, leading to errors. By studying how decisions are made and tasks are performed, human factors specialists can devise strategies to reduce mental overload, such as simplifying information presentation, automating routine tasks, and improving the clarity of communication among team members.<sup>[5]</sup>

Finally, enhancing patient safety involves a proactive approach to predict and prevent errors before they occur. This includes continuous training and simulation exercises for healthcare staff, fostering a culture of safety that encourages reporting and analyzing “near misses” and errors, and integrating feedback into system redesigns. The primary reason for applying human factors in healthcare is to create a forgiving

system that compensates for inevitable human mistakes and ensures that such errors do not harm patients. This human-centric approach not only improves safety but also enhances the overall quality of healthcare by making systems more responsive to the needs of both providers and patients.

### ***The Future of Human Factors in Healthcare and Using AI to Assist Healthcare Providers***

The future of human factors in healthcare is bright, with technology playing a pivotal role. Artificial intelligence (AI) is poised to transform the healthcare landscape by providing tools to predict patient deterioration, suggest optimal treatment plans, and automate routine tasks to free healthcare providers to focus more on patient care.<sup>[6]</sup>

AI can assist by analyzing vast amounts of healthcare data to identify potential risk factors and predict outcomes, enabling more personalized and timely interventions. Furthermore, AI technologies can be designed with principles of human factors to ensure they augment healthcare providers' capabilities rather than replace them. For instance, AI-driven diagnostic tools can offer decision support to doctors, ensuring that human judgment is enhanced rather than overshadowed.

Moreover, incorporating AI in training healthcare professionals on human factors principles—using virtual simulations that mimic real-world scenarios—can improve their readiness and adaptability in actual medical settings.<sup>[7]</sup>

In conclusion, as healthcare evolves, integrating human factors and AI will be crucial in designing systems that enhance provider performance and patient safety. Healthcare can achieve similar safety benchmarks by learning from industries like aviation, which has successfully minimized human error through human factors engineering. This interdisciplinary approach will ensure that future healthcare systems are technologically advanced, fundamentally safe, and human-centered.

### ***Practical Applications of Human Factors in Addressing Healthcare Challenges***

The application of human factors in healthcare has led to significant advancements in addressing a wide range of challenges, particularly in reducing medical errors, improving workflow efficiency, and enhancing patient safety. By focusing on the design of systems, processes, and tools that align with human capabilities, human factors science has proven instrumental in transforming healthcare delivery. Below are some notable examples and case studies highlighting human factors' practical applications in various healthcare settings.

#### **1. Improving Surgical Safety through Checklist Implementation**

One of the most well-known applications of human factors in healthcare is the introduction of surgical safety checklists. The World Health Organization (WHO) adopted this approach, inspired by aviation's use of pre-flight checklists to ensure safety. The WHO Surgical Safety Checklist was designed to reduce the incidence of preventable surgical complications by standardizing preoperative, intraoperative, and postoperative procedures.<sup>[8]</sup>

#### **2. Optimizing Emergency Room Workflow to Reduce Patient Wait Times**

Emergency rooms (ER) are dynamic environments where efficiency is crucial. Delays can lead to adverse patient outcomes, especially in critical cases. Human factors specialists have worked to optimize ER workflows by analyzing bottlenecks, reconfiguring physical layouts, and redesigning communication systems.<sup>[9]</sup>

#### **3. Reducing Medication Errors with Barcode Medication Administration**

Medication errors are a significant source of preventable harm in healthcare. Human factors research has been pivotal in designing systems that reduce the risk of such errors. One successful intervention is the Barcode Medication Administration (BCMA) system, which ensures that the right patient receives the right medication in the right dose at the right time.<sup>[10]</sup>

#### **4. Enhancing Patient Handoff Procedures to Prevent Information Loss**

Patient handoffs—when one caregiver transfers responsibility for a patient to another—are critical moments where communication failures can lead to errors. Human factors experts have developed standardized handoff protocols to ensure that essential information is consistently and accurately conveyed.<sup>[11]</sup>

#### **5. Designing Ergonomic Workstations to Reduce Provider Fatigue**

Healthcare providers often work long hours in demanding environments, leading to physical and cognitive fatigue that can compromise patient care. Human factors specialists have addressed this issue by designing ergonomic workstations that reduce strain and improve comfort, ultimately enhancing performance.

#### **6. Using AI to Support Decision-Making and Reduce Diagnostic Errors**

AI has the potential to significantly enhance human factors interventions by providing decision-support tools that reduce the cognitive load on healthcare providers. AI can analyze large datasets, identify patterns, and provide recommendations, thereby reducing the risk of diagnostic errors.<sup>[12]</sup>

## CONCLUSION AND IMPLICATIONS FOR TRANSLATION

Integrating human factors principles into healthcare settings involves a range of methodologies aimed at optimizing the interaction between healthcare providers and the systems they use. Key approaches include redesigning medical devices and interfaces to be more intuitive, restructuring workflows to reduce inefficiencies, and reconfiguring the physical environment to support safe and effective patient care. These efforts focus on minimizing the cognitive load on healthcare providers, reducing the likelihood of errors caused by complex systems, and ensuring that the overall design of healthcare processes aligns with human capabilities and limitations.

For example, human factors specialists often employ usability testing to assess and refine the design of medical equipment, ensuring that these tools are easy to use and less prone to user error. Simulation training is another vital methodology, allowing healthcare professionals to practice and improve their responses in high-pressure scenarios, thereby enhancing their readiness for real-world situations.

AI plays a crucial role in amplifying these efforts by providing advanced analytical tools that support decision-making, predict patient outcomes, and automate routine tasks. AI can analyze vast datasets to identify patterns and potential risk factors, enabling more personalized and timely interventions. In practice, AI-driven tools can assist in creating more effective treatment plans, alerting providers to potential errors before they occur, and optimizing the scheduling and allocation of resources in healthcare settings.

Moreover, AI can be designed with human factors principles in mind, ensuring that these technologies augment rather than complicate the work of healthcare providers. For instance, AI systems can be tailored to provide clear, actionable insights rather than overwhelming users with excessive data. This synergy between AI and human factors enhances the efficiency and safety of healthcare delivery and supports healthcare professionals' well-being by reducing cognitive overload and preventing burnout.

In summary, integrating human factors methodologies into healthcare, coupled with the strategic application of AI, represents a significant advancement toward a safer, more efficient, and human-centered healthcare system. By learning from the successes in aviation and other high-stakes industries, healthcare can achieve similar safety standards, ultimately leading to improved patient outcomes and a more resilient healthcare infrastructure.

### Key Messages

- The science of human factors combines knowledge and methods from various disciplines, such as psychology,

engineering, design, and statistics, to ensure safety and enhance human and system performance.

- With medical environments becoming increasingly complex, a deep understanding of human factor science can be leveraged to better understand and reduce errors and improve healthcare delivery.
- Integrating human factors in healthcare aims to create safer, more efficient systems supporting providers' ability to deliver optimal care.

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## COMPLIANCE WITH ETHICAL STANDARDS

### Conflicts of Interest

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### Declaration of Patient Consent

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### Use of Artificial Intelligence (AI)-Assisted Technology for Manuscript Preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript, and no images were manipulated using AI.

### Disclaimer

None.

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