1 Introduction

Human Factors and Ergonomics (HFE) is about designing work systems that support people and enhance both system performance and human well-being. The International Ergonomics Association (IEA) defines HFE 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 optimise human well-being and overall system performance'.[1]

Three features of this definition can be highlighted.

(1) HFE is based on a systems approach. This recognises that outcomes in complex settings like healthcare rarely stem from a single cause, but instead emerge from the dynamic interactions between people, tasks, technologies, physical spaces, organisational structures, and wider regulatory, socioeconomic, and political environments.[2] Accordingly, HFE provides a scientific foundation for understanding how these interactions shape work and produce outcomes.
(2) HFE is a profession that is practice-oriented, seeking to apply foundational knowledge to the design of work systems.
(3) HFE seeks to influence a broad range of outcomes, including safety, efficiency, usability, and well-being.

Although HFE originated in military, aviation, and industrial settings, its core concerns – issues such as system design, workflows, the design of work environments, and human well-being – are now increasingly recognised as important to healthcare. However, despite growing interest, HFE remains only partially understood in healthcare, where it is often narrowly associated with teamwork or aviation-style training,[3] and its practical application may be misunderstood or misrepresented.[4] HFE is not about finding 'the human factor' as the cause of accidents, nor is it limited to individual performance or 'non-technical skills'.

To show how HFE has evolved into the discipline and practice it is today, Section 2 outlines its historical development and introduces key models and methods that have shaped the field. Section 3 then presents examples of how HFE thinking has been applied in healthcare. Section 4 provides a critical reflection on the current status of HFE in healthcare, including its limitations and potential, while Section 5 offers an outlook on future directions for the field.

2 What Do We Mean by Human Factors and Ergonomics?

The IEA definition, adopted in 2000, provides a strong description of HFE, but several other definitions exist. Almost from the outset, there has been

considerable debate about what HFE stands for and how it should be defined. This debate continues as new problems emerge and as the discipline – and its scholars and practitioners – continue to adapt, reflect, and redefine their roles.

To clarify what HFE can offer, it is helpful to look briefly at its evolution from its origins during the wartime period of the early 1940s, before turning to its application in healthcare and some of the main models and methods used in this domain.

2.1 The Origins of Human Factors and Ergonomics

The discipline of HFE emerged from practical military problems experienced during the Second World War.[5] During this period, people had to manage more extreme environments and increasingly complex technologies and communication systems. Numerous incidents were attributed to human error, most notably in military aviation, where several aircraft crashed as pilots were struggling with fatigue, lack of adequate oxygen supply, and poorly designed cockpit layouts.

A well-known early example of HFE design thinking is the work of Paul Fitts and Alphonse Chapanis on B-17 and B-25 landing accidents. Pilots were mistakenly retracting the landing gear instead of lowering the flaps – initially labelled 'pilot error'. Fitts and Chapanis interviewed pilots and examined the cockpit. They recognised that the two controls were identical in shape and placed side by side, making confusion likely under stress. Their simple redesign using shape coding, in this instance a wheel-shaped knob for the gear and a wing-shaped one for the flaps, eliminated these errors almost immediately, reframing 'human error' as a design problem.

Patrick Waterson describes the history of HFE in the UK by chronicling the development of the Ergonomics Research Society (ERS), now the Chartered Institute of Ergonomics and Human Factors.[6–8] As in the US, several research institutes in the UK supported wartime efforts through improved design of equipment and controls. These include, for example, the Royal Air Force Physiological Laboratory (later the Institute of Aviation Medicine), the Cambridge Psychological Laboratory, the Medical Research Council Applied Psychology Unit, and the School of Anatomy at Oxford University. Their work on issues such as pilot fatigue and pilot error, radar operator effectiveness, and visual perception under stress led to improvements in control layouts, anatomically appropriate seat design for combat, and protective equipment.

The term 'ergonomics' is usually credited to Hywel Murrell, a psychologist at the Admiralty Naval Motion Study Unit. In 1949, Murrell convened a meeting of like-minded individuals to discuss the formation of a forum to exchange ideas

and expertise between the disciplines that had contributed to enhanced human performance during the wartime period. Initially, these disciplines were anatomy, physiology, and psychology. The meeting led to the adoption of the term 'ergonomics' and the establishment of the ERS as a formal community through which to develop foundational knowledge.

From the outset, it was challenging to define exactly what ergonomics was, and debate within the ERS and the wider ergonomics community about the scope of the discipline has persisted. Over the decades, the HFE community has had to adapt to technological and societal change in order to remain relevant. The wartime focus on relatively clearly defined, often manual, tasks shifted considerably during the 1960s with large-scale automation, and then again during the 1970s with the rise of business and office computing technologies. Issues of industrial ergonomics and safety-critical systems – such as nuclear power plant control room design – became increasingly important. This was accompanied by a move towards cognitive ergonomics and the notion of joint cognitive systems and cognitive systems engineering, i.e. the consideration of how people and computing technologies work together to carry out cognitive functions, with cognition distributed across people, tools, and environments.[9] Major accidents, such as the 1986 Chernobyl disaster, further broadened the scope to include (safety) cultures and organisational structures.[10,11]

HFE has always been multidisciplinary, drawing on fields such as anatomy, physiology, and psychology, and later industrial design, systems engineering, computer science, cognitive science, organisational sociology, and public health. Over time, specialisms – such as human–computer interaction and user experience design – have emerged, making it hard to draw clearly defined boundaries around HFE.

In its early years, HFE and the ERS in the UK were regarded primarily as an academic field and a forum for bringing together different disciplines, rather than as a professional practice. Over time, tensions emerged between these multidisciplinary roots and the growing need for consistent, applied professional work. These tensions helped drive the development of HFE as a defined profession. In 1977, the ERS reflected this shift by changing its name to the Ergonomics Society, dropping the explicit focus on research. In 2009, the name changed again, this time to the Institute of Ergonomics and Human Factors, in part to reflect international usage of the term 'human factors'. In 2014, the institute was awarded a royal charter and became the Chartered Institute of Ergonomics and Human Factors. Today, around 600 chartered ergonomists are registered.

This institutional development reflects a broader maturation of the field, from a multidisciplinary forum towards a defined profession with a shared set of

principles and practices. While the debate continues about the scope of HFE and the relationship between foundational research and applied practice, there is consensus about its core tenets. HFE practice is fundamentally about designing sociotechnical systems and should always:

(1) take a systems approach
(2) aim to design interactions
(3) focus on two closely related outcomes, that is, system performance and human well-being.

With these historical roots and disciplinary foundations in mind, the next section explores how HFE has evolved within, and has been applied to, the healthcare domain.

2.2 Healthcare Human Factors and Ergonomics

As discussed in the previous section, HFE is fundamentally concerned with the design of interactions in sociotechnical systems to enhance system performance and human well-being. Healthcare presents a compelling but complex setting for the application of HFE approaches.

2.2.1 Physical Ergonomics

One of the early areas where HFE was applied in healthcare was physical ergonomics during the 1990s, particularly in the design of buildings, equipment, and systems to prevent musculoskeletal disorders among healthcare workers.[12] Work in operating theatres, midwifery, physiotherapy, radiography, and ambulance services is often repetitive, requires similar movements and postures for extended periods of time, and frequently involves lifting heavy loads. In nursing and allied health professions, manual patient handling represents a major musculoskeletal risk, and the application of physical ergonomics has been shown to be an effective approach for assessing and mitigating such risks.[13]

Posture analysis studies using HFE techniques, such as Rapid Upper Limb Assessment (RULA) and Rapid Entire Body Assessment (REBA), have shown how patient-handling tasks are associated with high rates of harmful postures, particularly when staff are unable to modify their environment or the patient's position.[14] Reviews of the literature highlighted the limited value of traditional manual handling education alone, which has little long-term impact on injury rates.[15,16] Instead, multifactorial interventions that combine equipment provision, risk assessment, redesign of the work environment, and changes to work organisation – alongside training – are most likely to succeed.[12]