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## Twelve tips for embedding human factors and ergonomics principles in healthcare education

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### ABSTRACT

Safety and improvement efforts in healthcare education and practice are often limited by inadequate attention to human factors/ergonomics (HFE) principles and methods. Integration of HFE theory and approaches within undergraduate curricula, postgraduate training and healthcare improvement programs will enhance both the performance of care systems (productivity, safety, efficiency, quality) and the well-being (experiences, joy, satisfaction, health and safety) of all the people (patients, staff, visitors) interacting with these systems. Patient safety and quality improvement education/training are embedded to some extent in most curricula, providing a potential conduit to integrate HFE concepts. To support evolving curricula and professional development at all levels – and also challenge prevailing “human factors myths and misunderstandings” – we offer professional guidance as “tips” for educators on fundamental HFE systems and design approaches. The goal is to further enhance the effectiveness of safety and improvement work in frontline healthcare practice.

### Introduction

In 1999, the US Institute of Medicine estimated 100,000 deaths/year resulted from “medical error” (IOM 1999). Recent analyses suggest that this is closer to 200,000, making it the third leading cause of death in the United States (Blasiak et al. 2014). Similar patient safety problems are seen in most modern healthcare systems worldwide, including the United Kingdom (Health Foundation 2013). The failure to improve over the last 18 years is partly attributed to complexity of healthcare systems but also to a lack of engagement with professional safety scientists and there is increasing realization that Human Factors/Ergonomics (HFE) can support healthcare safety and quality improvement (QI) initiatives (HEE 2015; CQC 2016).

HFE, as an academic discipline and professional practice, offers theory and knowledge from over 50 years of experience in similarly complex industrial sectors such as defense, petro-chemical, rail and aviation, which maintain comparatively low incident rates despite operating within inherently risky environments (Hopkins 2007; Le Coze 2016). However, healthcare is particularly complex, dynamic and interdependent, not least because of patient variability, multiple care interactions, incomplete data, managing uncertainty, changing regulatory landscapes and chronic underfunding (Carroll and Rudolph 2006).

HFE approaches are useful because they share three fundamental characteristics often overlooked in traditional safety and QI efforts by (i) taking a systems approach; (ii) being design-driven and (iii) focusing on dual outcomes of optimizing system performance and improving human well-being (Dul et al. 2012). Professional ergonomists (known as Chartered Ergonomists and Human Factors Specialists in the United Kingdom – postnominal C.Erg.HF; Certified

Professional Ergonomists in the USA, postnominal CPE) can help achieve these goals through assessing problems and designing, implementing and evaluating interventions, by seeking to match demands of the environment to capabilities (and limitations) of staff and patients.

### Safety and improvement education

There is an increasing focus on safety in healthcare education but progress is slow with little direction for teaching provided by professional, statutory and regulatory bodies. The World Health Organization (WHO 2011) developed a patient safety curriculum, but little is known about how providers ensure learners develop safety competencies, and even less about integrating fundamental HFE concepts (Gurses et al. 2012; Cresswell et al. 2013; Carayon et al. 2014).

Constructively aligned healthcare curricula, reflecting professional behaviors are articulated in course outcomes. However, key weaknesses have been identified in terms of:

1. The location of safety within professional roles may not be clear.
2. Clinical students/trainees learn about safety mostly via a hidden curriculum (implicit learning in the practice environment Cresswell et al. 2013).

Given the importance of practice roles in driving educational content, teaching staff must understand hidden curricula in practice. We propose HFE concepts should be central to patient safety and QI in clinical programs – including Continuing Professional Development (CPD) – in both delivery and design. However, because of limited capacity in healthcare HFE expertise, teaching staff may

welcome guidance on incorporating HFE principles and methods. This is particularly important given recent evidence suggesting potential for fundamental misunderstandings of the purpose of HFE applied in healthcare (Catchpole et al. 2007; Russ et al. 2013).

## Tip 1

### **The HFE core concept is to jointly optimize systems performance and the wellbeing of people**

The systems approach is used in HFE to integrate knowledge about interactions from affiliate disciplines including engineering, cognitive and organizational psychology, interaction design, human sciences, and organizational management (Wilson 2000). Understanding and applying the systems approach must be the starting point for embedding HFE. It is a fundamental HFE concept and underpins all the other tips.

Systems are defined as “a set of inter-related or coupled activities or entities (hardware, software, buildings, spaces, communities and people) with a joint purpose” (Dul et al. 2012). They have links (state, form, function and causation) between the activities/entities which change and modify both the state(s) and interactions within given circumstances and events. [A system] is conceptualized as existing within a boundary; it has inputs and outputs which may connect in many-to-many mapping, and ... the whole is usually greater (more useful, powerful, functional etc.) than the sum of its parts” (Wilson 2014). If activities/entities are tightly coupled changes to one part immediately affects others and the impact is rapidly felt in other (often distant) parts of the system. HFE systems analyses explore both entities and their interactions.

The first step is defining the boundary; what is (and is not) part of the system. A physical boundary (transition) could be the handover (physical movement) of patients from surgery to intensive care (Catchpole et al. 2007), whereas a service boundary could be the transfer of information between a screening database and a disease register. Service boundaries are much softer than physical boundaries and may not be signposted with clear warnings.

Secondly, systems modify their state in response to circumstances and events. They are dynamic (not stable), and despite constant change, manage (for the most part) to fulfill their purpose, as there may be multiple paths to the same outcome. This gives rise to the concept of *emergence*, where outcomes result from the interaction of many parts and are not necessarily predictable. Sometimes, emergent outcomes are desirable to identify previously unknown capabilities of a product, process or role; for example the phosphodiesterase inhibitor sildenafil was originally tested as a treatment for angina (with disappointing results) but eventually recognized as effective in treating erectile dysfunction (Viagra<sup>TM</sup>). Equally, emergent outcomes may be negative.

When systems are poorly designed, users may adjust their behavior (including divergence from standard operating procedures) to achieve the intended systems outcomes and the effect may be desirable. However, other parts of the system (e.g. managers, guideline developers or policy makers) may not be fully aware of this behavior adjustment

(“work-as-done”; practice) to policies, protocols and procedures (theory or “work-as-imagined”). This is described as “a state of ignorance” by Hollnagel (2012) and conflicts with the way healthcare safety structures currently work.

In the WHO multiprofessional patient safety curriculum guide, safety is defined as “the prevention of errors and adverse effects to patients associated with healthcare” (WHO 2011). This concerns us for two reasons: firstly, it separates patient safety from the rest of the organizational systems (including staff safety). Secondly, it describes an error-reductionist approach (known as Safety-I) which seeks to identify and rectify the root cause(s) of “errors” and often focuses on people rather than wider systems when trying to understand and resolve issues. The recognition that systems, despite their inherent imperfections, operate safely most of the time (through resilience adjustments, Tip 9) has been theoretically described as Safety-II (Hollnagel 2012; Wilson 2014).

This is an important point for healthcare educators as, in our opinion, current patient safety teaching focusses almost exclusively on Safety-I concepts and approaches. We suggest (Tip 1) that there needs to be a balance, with an increased focus on Safety-II to optimize overall systems performance and human well-being.

## Tip 2

### **Teaching faculty must be competent to deliver theory and practice (knowledge and skills)**

Lack of knowledge and skills about systems is arguably the biggest challenge for embedding HFE in education and training. Moving to a systems approach is no small undertaking and a minimum level of theoretical knowledge and practical expertise (competency) is required (see Tip 12).

HFE is an applied discipline and there is an argument for developing both pan-healthcare HFE learning outcomes (Tip 7) and a healthcare HFE methods toolbox. There are many HFE tools (Stanton et al. 2013), but most require a minimum HFE competency for correct application and interpretation of results. We are outlining two families of HFE tools (systems modeling and task analysis) which could also be used for curriculum design (Tip 11).

1. Systems modeling tools include the Systems Engineering Initiative for Patient Safety (SEIPS 2.0; Holden et al. 2013), which describes a generic interactive work system in which people use tools and technologies to complete tasks (in specific physical locations) and are influenced by social, organizational and external factors. How people interact with this wider system largely determines work outcomes, for example, related to safety, efficiency or patient experience.
2. Task analysis tools are used to investigate job task requirements with respect to human capabilities with outputs including, for example, visual representations (e.g. link analysis; Kirwan and Ainsworth 1992; Zhao et al. 2014), cognitive modeling for decision-making (e.g. hierarchical task analysis; Annett and Duncan 1967; Stanton 2006).

We suggest (Tip 2) that a minimum HFE competency (Tip 7) is needed for appropriate application of HFE tools (including systems modeling and task analysis) and interpretation of related results.

### Tip 3

#### **Practice what you preach: Consider adopting human-centered organization principles**

We suggest that using HFE approaches for academic activities will reap benefits from the hidden curriculum, whereby the safety values and attitudes of learners are more influenced by implicit learning from in-practice behaviors than from taught curricula.

One example is the concept and operation of “Just Culture” (Dekker and Breakey 2016) to underpin and balance safety and professional accountability in the workplace. In other sectors, international standards are used to ensure products and services are of appropriate quality, through shared understanding of “good quality.” This approach may help with the development of accessible, internationally relevant educational curricula.

Creating and maintaining a Just Culture is complex. Key elements include open reporting of incidents and transparency in information handling, as well as learning for future safety improvements. HFE supports a participatory approach (Tip 8), so feedback should be built into systems to engage learners in active change. Just Culture may require education providers to reconsider their regulatory role, including Fitness-to-Practise (FtP) procedures. FtP is considered by regulators to support patient safety, by defining minimal acceptable standards of practitioner behavior but related procedures should deal fairly with individuals whose professional practice has been called into question (Horsfall 2014).

We suggest (Tip 3) that an HFE approach for academic activities offers a more visionary way to influence hidden safety curricula by example.

### Tip 4

#### **Recognize what HFE is...**

What do HFE interventions look like? HFE is a very specific way of thinking and doing which needs to be fully embraced if benefits are to be realized. HFE approaches should define the scope of any project or intervention, establishing the high-level values and goals relevant to the specific context. Healthcare systems will range from micro-systems (humans performing single tasks or using tools) through mesosystems (working as part of teams/organizations), right up to the complex sociotechnical (macro) system. HFE interventions may focus on optimization of a microsystem, but there will always be clear mapping of the relationship of the micro with the larger (macro) system, that is, “the systems approach.”

HFE is relevant to all stages of the life cycle of a product or service, from early stages of service planning and product/building design, through implementation and evaluation and re-design. For example, in the UK Ministry of Defense, this approach is mandatory with Joint Service Publications for Human Factors Integration (MOD 2015a,

2015b) in all Defense acquisition projects to ensure that the HFE activities are carried out “effectively, efficiently and at appropriate times in a project”.

Tip 4 highlights the importance of incorporating HFE from project inception across micro, meso and macro systems.

### Tip 5

#### **... and recognize what HFE is not**

Tip 5 can be defined in relation to Tip 4: if an intervention does not show evidence of a systems approach etc., then it is not HFE. Is it this simple?

We feel this issue warrants its own tip due to the history in healthcare of confusing HFE with non-technical skills training (particularly for surgical team working/communication, Greig et al. 2015). Nontechnical skills (NOTECHS) training usually focuses on behavioral safety solutions using “technical” to mean “specialist,” rather than “technology-related” (as used in HFE for sociotechnical systems; Wilson 2000, 2014). This has resulted in the exclusion of a systems approach and has led many clinicians to the mistaken belief that aviation-style training (e.g. crew resource management) is HFE, despite a lack of systems theory, HFE integration, human-centred design or HFE analysis techniques teaching (Saleem et al. 2011; Hignett et al. 2013; Russ et al. 2013).

Behavioral approaches, such as NOTECHS training, arguably make assumptions that assessing and changing behavior at the person level will improve safety based on the notion that ‘human error’ (and performance) “causes” most incidents (Safety-I, Tip 1). The problem with seeing incidents as resulting from “failures of people” (whether intended or not) is that control measures become focused on limiting error, which invariably involves directing interventions at personal behavior modification, with a heavy focus on training (Russ et al. 2013). This is completely counter to the systems approach and fails to recognize that many successful work outcomes are achieved because of individual performance variability and adaptability matched to human capabilities and limitations.

It is important (Tip 5) to communicate that HFE is not behavior-based training and also rarely identifies a single “root cause” after a systems analysis. Additionally, an HFE intervention would not focus on requiring people to adapt behaviors (nonspecialist skills) to accommodate poorly designed systems of work and/or technology.

### Tip 6

#### **Do not throw the baby out with the bath water: Recognize that HFE and QI can offer synergies**

Quality improvement (QI) theory and methods have been growing in prominence in healthcare education and practice for 30 years (Hignett et al. 2015). While QI and HFE have common origins, QI often focusses narrowly on “process”, whereas HFE considers the broader systems of which the process will be an entity. We are not suggesting HFE will replace QI but recognize that one obstacle to embedding HFE in education and training is misunderstanding the relationship between these two disciplines.



For example, commonly applied QI tools such as Process Mapping, Plan-Do-Study-Act (PDSA) cycles, Lean and Six Sigma are not HFE methods.

One key achievement of QI has been empowerment of frontline staff in challenging managerial “work-as-imagined” attitudes. However, this local solution approach can prevent delivery of measurable outcomes where local teams do not have appropriate knowledge and expertise to apply a systems approach (Ranji et al. 2007; Dixon-Woods et al. 2014). Sometimes, in response to a locally identified need, there can be a “knee-jerk” reaction that leads to failure to (i) consider the evidence of the need for change and (ii) ensure the design of the intervention is rigorous, including the identification of an appropriate methodological framework and robust outcome measures (Taylor et al. 2014). This has been reinforced by the iterative PDSA cycle as a solution-focused QI strategy where a solution is proposed and repeatedly eliminated until an acceptable or “square-peg” solution is found (Hignett 2001). This may account for why evidence to support the application of PDSA cycles is limited (Taylor et al. 2014), although Reed and Card (2016) argue that problems are exacerbated by oversimplification of the method in its transfer to healthcare. In contrast, HFE specialists take a user-centered task analysis approach (Tips 2, 3, 4), aiming for optimal rather than acceptable solutions.

Much can be achieved by exploring how QI and HFE may be used synergistically (Hignett et al. 2015). HFE, with its understanding of (1) human capabilities and limitations and (2) how humans interact with complex sociotechnical systems, is well placed to identify needs and develop interventions, while QI has a track record in making changes but may benefit from a more rigorous approach. The scientific theory informing HFE practice can act as a discipline role model supporting QI as it matures, while the broad acceptance of QI within healthcare can smooth the way for the arrival of wider HFE use. Most curricula and improvement programs provide opportunities for practicums and QI project activity; a combined approach could explore real-life problems within the context of a complex socio-technical system, to inform more meaningful design and evaluation of improvement interventions.

## Tip 7

### **Curriculum design and content should be driven by learning outcomes to develop appropriate HFE competencies**

HFE professional behavior is guided by Core Competencies (Table 1) in the same way as other professional regulators (General Pharmaceutical Council 2001). Performance elements include systems approaches to analyze, understanding risk management and developing robust HFE interventions to improve systems performance and human wellbeing. Many of these criteria fall within the domain of the HFE expert and would not be applicable to healthcare professionals using a limited range of HFE tools within defined contexts. Three levels are suggested for healthcare professionals:

- Basic understanding of HFE theory and practice and their role in the clinical workplace

**Table 1.** HFE competencies (modified from IEA 2001).

Unit 1. Ergonomics/human factors (E/HF) principles
1 Ability to identify and apply methods of analysis, evaluation and validation with respect to human interfaces for tasks, activities and environments
Unit 2. Ergonomics/human factors (E/HF) theory and practice
2.1 Understands theoretical and practice bases for analysis of human interactions
2.2 Understands the theoretical and practice bases for (re)design of human interfaces (physical and mental)
2.3 Understands the theoretical and practice bases for data collection and analysis relating to E/HF
Unit 3. Human capabilities and limitations
3.1 Understands the theoretical and practice bases for E/HF relating to physical capabilities and limitations
3.2 Understands the theoretical and practice bases for E/HF relating to psychological and social capabilities and limitations
Unit 4. Design and development of systems, including products, tasks, jobs, organisations and environments
4.1 Understands the theoretical and practice bases for E/HF relating to design and development of systems
4.2 Utilizes a systems approach to the human-aspects of the specification, design, assessment and acceptance of products, services and human factors interventions
Unit 5. Professional skills and implementation
5.1 Understands role of E/HF in change strategies
5.2 Develops appropriate recommendations for education and training in relation to E/HF principles
5.3 Supervises the application and evaluation of the E/HF plan
5.4 Shows a commitment to ethical practice and high standards of performance and acts in accordance with legal requirements

- Application of risk management practices within scope of own professional (and educational) domain (e.g. health and safety; organizational psychology, quality improvement science)
- Knowledge of mechanisms for seeking professional guidance from a competent person (minimum PGCert HFE) or expert (e.g. Member/Fellow of CIEHF in UK or CPE in USA) for (re)design of systems and interfaces

We suggest that healthcare educational HFE outcomes should be shared across disciplines as, while the context might be different, there are commonalities so shared competencies will strengthen interprofessional working. Improved shared understanding and better quality assurance could be achieved by healthcare educational regulators and curricula designers working with professional HFE bodies (i.e. federated societies of the International Ergonomics Association; CIEHF in the United Kingdom; Board of Certification of Professional Ergonomics (BCPE) in USA) to support a level of HFE competency on completion of healthcare educational courses and specialty/vocational training programs.

We suggest (Tip 7) HFE competency can be signposted to support professional practice within a code of conduct (CIEHF) and additional education.

## Tip 8

### **Use the participatory approach central to HFE to strengthen your specific curriculum or program of training**

When much HFE learning is implicit through the hidden curriculum (Tip 3), there may be no explicit or apparent discord with the articulated curriculum. To maximize success, we suggest that space should be provided to actively promote

recognition of mismatches. This requires partnership with students and other learners as they are the “experts” about the hidden curriculum. By engaging in a participatory process with learners to explore what learning really takes place and how, both in learning environments and in work settings, we can begin to gain better insights that will inform co-design of more realistic and effective curricula.

This type of partnership is encouraged by, for example the Quality Assurance Agency for Higher Education, to improve the learning experience. Exploring the hidden curriculum would address this agenda in a mutually beneficial way.

## Tip 9

### ***Recognize that to err is not just human, but is highly desirable as part of a learning strategy to develop transferable skills in building resilient systems***

It is not possible to prevent all errors as they are considered a normal part of work (and learning) within complex sociotechnical systems (Perrow 1984; Sagan 1993). Consequently, the least effective approach to patient safety teaching is to advocate a zero-error approach, as even focusing on error reduction strategies is of limited value.

Students, trainees and learners need opportunities to consider safety in day-to-day routine, through what airlines refer to as “abnormal procedures” and emergencies. The focus should not necessarily be on outcomes, but on the system’s resilience to absorb inevitable errors, dampen impacts and deliver acceptable outcomes.

Exploring factors that mitigate risk requires opportunities to make errors in the learning environment and follow the trajectory to the natural end. This may seem counter-intuitive, but is a core HFE approach to understanding why things go wrong in complex healthcare systems and how to respond, learn and improve more effectively. Having identified potential mitigations, systems can be re-designed, tested and evaluated.

This may be a paradigm shift for some educators and professions. For example, pharmacists are recognized as risk averse, with safety strategies aimed at error elimination. This attitude is likely to be exacerbated by a legislative framework viewing errors as criminal offenses (Langley 2013) and an educational regulatory framework requiring providers to fail students making errors affecting patient safety during assessment (General Pharmaceutical Council 2001). HFE frameworks would support these transitions to a more up-to-date understanding of system complexity and integration of core safety science concepts and approaches. Embedding HFE principles in educational curricula would thus support students and trainees in learning from ‘errors’ through supported educational activities.

## Tip 10

### ***Build on what is already there***

It is likely that many curricula have “human factors” teaching, even if it is focused on “non-technical skills” (see Tip 5) or “patient safety” training. A first step should review whether content includes the HFE fundamental principles (Table 1) in collaboration with Chartered HFE experts

(United Kingdom) or international equivalents from IEA-Federated Societies worldwide.

By identifying what is taught (and where), gaps between this and a more robust HFE educational model can be defined. Our suggestion is to develop existing activities to close this gap as evidenced by recent exploratory HFE work in general practice specialty training (McKay et al. 2016). For example, a NOTECHS training scenario could be given a backstory, perhaps showing how robust application of a systems framework such as the SEIPS model had identified communication as a “person factor” critically underpinning a specific process. An understanding of laboratory risk management may be a good place to introduce systems concept to students, trainees and learners. Bigger change (Tip 10) may be best effected by making curriculum review part of a broader safety strategy, developing an HFE framework for re-accreditation.

## Tip 11

### ***Take an interprofessional education (IPE) perspective to curriculum design and content***

The goal of systems optimization can only happen if all relevant stakeholders are engaged and making a contribution. Healthcare is largely delivered by teams, so it makes sense that HFE activity occurs within curriculum spaces where professions interact.

Realistic stakeholder mapping and engagement is key. Dul et al. (2012) propose four groups for HFE interventions:

1. Systems actors: healthcare staff, patients (service users), carers, etc. For IPE, this is often the only group involved but may be the least able to effect change.
2. Systems experts: including HFE professionals
3. Systems decision makers, such as senior executives and managers, with immediate power to effect change.
4. Systems influencers; political bodies, policymakers, regulators, etc.

Effective IPE is challenging, partly because robust research is limited (Reeves et al. 2013), and logistical complexity means IPE often sits outside the curriculum and is not associated with learning outcomes (Gilligan et al. 2014). Professional roles are poorly understood and medical hierarchy may contribute to tribal silos which can undermine team working. Gilligan et al. (2014) recognize the contribution of IPE to the hidden curriculum, suggesting that academics constantly refer to the importance of inter-professional working, yet fail to deliver effective IPE.

We suggest (Tip 11) that using HFE as a focus for assessed IPE activity may address obstacles to designing curricula underpinned by the systems approach.

## Tip 12

### ***Build HFE capacity and capability creatively***

There is a skills gap with respect to HFE expertise in healthcare internationally (Catchpole 2013). HFE experts have generally undertaken an accredited postgraduate qualification and the numbers of these are small. In developing an effective implementation strategy for HFE-based curricula, we

need to enrich the numbers at all levels, but related educational development should, where feasible, include input from qualified and regulated HFE professionals to ensure both credibility and that professional standards are adhered to. One answer is to enrich the expert pool by healthcare disciplines building collaborations with other disciplines.

Accredited shorter courses have been developed and are used to raise HFE awareness (Hignett et al. 2016). In the United Kingdom, for example, some NHS Trusts, Boards and Clinical Commissioning Groups are funding postgraduate academic training for a small number of “champions” with responsibility for supporting others in HFE practice and educational provision. This should strengthen the quality of the HFE aspects of the hidden curriculum for students on placements, and could be used for developing “train the trainer” activities to support building basic competency with fundamental concepts and approaches that can be applied in frontline care (Tip 1).

A final recommendation is for healthcare staff to develop HFE expertise by setting objectives within existing reward and recognition frameworks for teaching and learning, and at postgraduate level through CPD activity and participation in formal safety and improvement initiatives.

## Discussion and conclusions

An important opportunity exists for current undergraduate curricula, postgraduate training and healthcare safety and improvement programs to be considerably strengthened by the integration of HFE theory and methods. While current guidance for patient safety teaching appears to recognize this, it is apparent that the potential impact is compromised by conflation of HFE and a limited and potentially misleading focus on “factors of the human.” The WHO multiprofessional patient safety curriculum (for example) is one of the few resources available to healthcare faculty for designing and delivering curricula that support the development of safety competence. While this document contains a great deal of excellent guidance, its practical application is perhaps undermined by an apparently conflicted understanding of HFE. While Human Factors is described adequately as the “*science of the interrelationships between humans, their tools and the environments in which they work,*” it occupies a separate topic from systems thinking which is, of course, a critical core element of HFE. Similarly, Human Factors is described separately from a number of other topics, including error management which, again, we would argue are all fundamental within the domain of HFE. Furthermore, there are multiple references to the output of Human Factors approaches being focused on error reduction. While this is one possible outcome, HFE approaches recognize the inevitability of error and seek to design resilient systems which absorb error and ameliorate its impact on patient and staff harm (and overall system performance). Part of the work around developing the WHO curriculum involved the development of an internationally agreed set of key concepts and terms (Runciman et al. 2009). The term “system” is not defined (although “system failure” and “system improvement” are included). Furthermore, the WHO definition of safety is given as the “*reduction of unnecessary harm associated with healthcare to an acceptable minimum.*” An HFE definition of

safety would link much more closely to its systems roots: safety would be defined as the level of system performance required to keep the incidence of harm to As Low As Reasonably Practical (ALARP) – <http://www.hse.gov.uk/risk/expert.htm>. While the guide includes extensive reference to pedagogical approaches to teaching safety, this is very general and does not refer specifically to the development of HFE competencies. The guidance “tips” we describe address this gap, providing a preliminary platform for healthcare educators to explore how best to consider integration of key fundamental HFE principles within existing curricula and related educational programs. The tips include the systems framework (Tips 1, 3), HFE tools and competency (Tips 2, 7), misunderstandings (Tips 4, 5) and ideas for implementation (Tips 6, 8, 9, 10, 11, 12). We believe that these tips will support the multi-disciplinary goal of enhancing the performance of care systems (productivity, safety, efficiency, quality) and the well-being of all the people (patient outcomes, staff presenteeism) interacting with health and social care systems. Finally, we also recognize that healthcare educators would perhaps be best supported through the provision of case studies demonstrating the impact of application of these “12 Tips” and compiling a suitable resource will be a key focus of near-future work.

## Disclosure statement

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

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