Human Factors Engineering for Quality Improvement and Research in Health Care

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Tools
Cognitive walk-through, contextual inquiry, focus groups, heuristic analysis, interviews, prototyping, questionnaires and surveys, the Systems Engineering Initiative for Patient Safety model, task analysis, time and motion studies, and usability evaluation, physical ergonomics, cognitive ergonomics, microergonomics, work system, process, outcomes

Definition

Human factors engineering (HFE) is "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"(http://www.iea.cc/whats/index.html).

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Domains of Specialization Within HFE

There are three sub-domains within the discipline of HFE: physical ergonomics, cognitive ergonomics, and macroergonomics [1].

- *Physical ergonomics* focuses on how to (re)design physical environments (e.g., physical layout of an intensive care unit) or tools (e.g., ergonomics and design of laparoscopic surgery instruments) to improve human performance.
- *Cognitive ergonomics* develops solutions to improve overall system performance considering the cognitive abilities and limitations (e.g., limitations in working memory and attention) of human beings. Common areas of focus under this sub-domain include better management of mental workload, improvement of decision-making, enhancement of human-computer interaction, and development of effective training programs.
- *Macroergonomics* uses a variety of HFE tools and methods to (re)design the overall work system, taking into account the interactions and fit between different system components. Enhancing teamwork and coordination, improving safety culture, and redesigning jobs (e.g., scheduling breaks, changing the duration of shifts) are examples of improvement efforts that can benefit from macroergonomics.

Conceptual Model to Guide Health-Care Quality Improvement and Research Efforts

According to the Systems Engineering Initiative for Patient Safety (SEIPS) model (Fig. 1), a human factors engineering model of quality and safety of care, the performance and outcomes (e.g., readmission rates, health-care acquired infections) in any health-care organization, depends on the design of the work system (structure) and the related processes

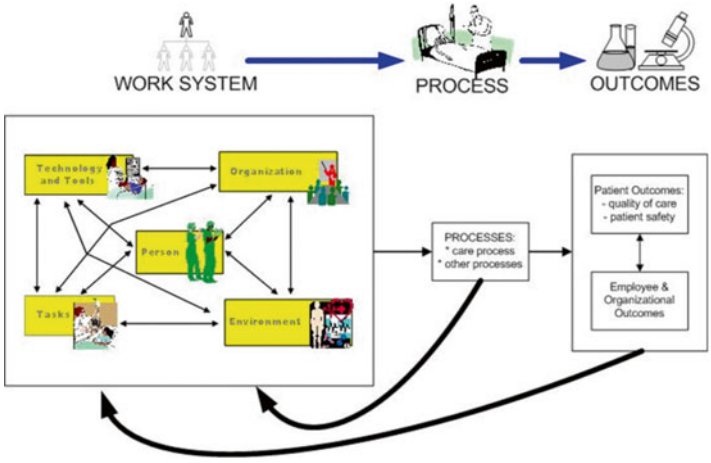

FIG. 1 Systems Engineering Initiative for Patient Safety (SEIPS) model (Carayon et al. [2], p. i51)

(both care processes and other processes). HFE experts study the interactions between individuals and elements of the work system in which they work including physical environment, tasks, tools and technologies, teamwork, and organizational environment. They then develop solutions (i.e., redesigning particular aspects of the work system) while systematically considering the interactions among different work system elements to avoid any potential unanticipated negative impact of the proposed solutions [2].

Human Factors Engineering Methods

Human factors engineers use a variety of qualitative (e.g., interviews, focus groups) and quantitative methods (e.g., questionnaire, time and motion studies) for data collection and analysis. A sample list of these methods is given in Table 1. It is important to note that Table 1 provides descriptions of only a very small subset method; interested readers are

TABLE 1 A sample list of methods and tools used in human factors engineering

Method/ Tool name	Definition	Abbreviated example
Cognitive walk-through	A step-by-step process of having the users talk about their thinking and action-taking process while performing specific predefined tasks. It can be done while the users are performing or after they completed performing the task. A very common cognitive-walk-through method is think-aloud, where the users talk about their thinking process while they perform the tasks. As medical workflows involve multiple processes, walk-throughs can be especially useful in determining user cognitive processes to better multiple systems	The physicians being asked to explain their thinking while accessing a specific lab value of a patient through the electronic health record
Contextual inquiry	Unobtrusive observation of users performing relevant tasks in their natural working environments, coupled with short questioning	A physician is observed while performing her duties in the ICU and is asked short questions about the tasks she is performing
Heuristic analysis	Involves the evaluation by clinical and/or human factors/ usability engineering experts of the technology in how it conforms to human factors/usability rules	A team of human factors experts determining and comparing different brands of medical devices in terms of their design and usability before a purchasing decision is made

Interviews	Systematic and in-depth data gathering regarding a topic/focus area by asking detailed questions. Interviews can be structured (a strict set of questions), semi-structured (a few open-ended questions coupled with specific probes), and/or unstructured (no previously determined set of questions)	Physicians and nurses being interviewed about their most commonly encountered problems involving the physical layout and design in their unit
Prototyping	Developing a simple representation of a new design alternative (e.g., information technology, medical device, physical layout) and its components through rapidly developed, inexpensive models, which, in most cases, are not fully functional but fulfill the needs of the testing for functionality purposes. Multiple prototypes can be developed to simulate the new design alternatives, and simulations can be used to better understand the functionalities and common scenarios	Developing a mock-up of user interfaces of a critical component of an electronic health record system for experimentation with physicians and nurses
Questionnaires and surveys	Written questions and surveys allow relevant opinion and information collection regarding various work system elements. They can also be very useful in evaluating the impact of an intervention on the work system, processes, and outcomes. Surveys can be administered in person, via postal mail, on the phone, and online	Surveying patients and family members for their opinions regarding the redesigned hospital discharge process

(continued)

Table 1 (continued)

Method/ Tool name	Definition	Abbreviated example
Task analysis	Systematic methods to produce detailed descriptions of tasks and their corresponding sub-activities	Determining which exact tasks are repetitively done in an ICU by a nurse, how long each task and subtask lasts, and work-arounds and potential risks associated with each task
Time and motion studies	Determining the exact typical motion and the typical time it takes to complete a task and its components correspond to time and motion studies. Video recording the tasks and using stopwatch are common activities accompanying time and motion studies	Using time and motion analysis to determine what percentage of nursing time is spent on direct patient care and indirect patient care (e.g., walking in the unit, documentation)
Usability evaluation	Involves understanding the exact nature of interactions between users and technologies	Laboratory testing of a newly developed information technology

encouraged to consult other resources (e.g., [3]) to learn more about the HFE methods.

Application Domains

Human Factors Engineering can be used in almost all aspects of health-care quality improvement efforts (See [4] for detailed examples). Some examples of the use of HFE in health care are listed below:

- To reduce health-care acquired infections through work system redesign such as standardization, reducing ambiguity in systems [5], and improving culture of safety
- To assess risks associated with a new electronic health record system implementation proactively (before implementation) and to develop appropriate strategies with the purpose of mitigating these risks
- To conduct effective root cause analysis and medical-error accident investigations for creating more effective learning organizations
- To evaluate and compare different brands of medical devices from a usability point of view in order to inform purchasing decisions
- To improve care coordination and teamwork among clinicians
- To identify patient and family member needs and to develop solutions for increasing the patient and family centeredness of care

If you have any questions about the information covered in this chapter or other medical safety and quality improvement-related topics, please contact us at http://www.medicalqualityandsafetyforum.com. The website will also provide a forum where you can ask specific questions about your safety and medical quality improvement projects or mentor upcoming medical quality leaders.

References

1. Gurses AP, Ozok AA, Pronovost PJ. Time to accelerate integration of human factors and ergonomics in patient safety. BMJ Qual Saf. 2011;21(4):347–51.
2. Carayon P, Hundt AS, Karsh B-T, Gurses AP, Alvarado CJ, Smith M, Brennan PF. Work system design for patient safety: the SEIPS model. Qual Saf Health Care. 2006;15 Suppl 1:i50–8.
3. Stanton NA, Salmon PM, Rafferty LA, Walker GH, Baber C, Jenkins DP. Human factors methods: a practical guide for engineering and design. 2nd ed. Burlington: Ashgate Publishing; 2013.
4. Carayon P. Handbook of human factors and ergonomics in health care and patient safety. Boca Raton: CRC Press; 2011.
5. Gurses AP, Seidl K, Vaidya V, Bochicchio G, Harris A, Hebden J, Xiao Y. Systems ambiguity and guideline compliance: a qualitative study of how intensive care units follow evidence-based guidelines to reduce healthcare-associated infections. Qual Saf Health Care. 2008;17(5):351–9.