

## **The use of mixed methods in healthcare human factors and ergonomics research**

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**Abstract.** We conducted a systematic literature review on the use of mixed methods in healthcare human factors and ergonomics research. A total of 53 papers published in 39 journals before February 2013 were identified. These studies tackle a range of human factors and ergonomics (HFE) issues, in particular related to various types of information technology. A variety of methods were used to collect qualitative and quantitative data: primarily interview, survey and observation for qualitative data, and survey for quantitative data. Healthcare HFE research could benefit from using formal mixed methods research approaches. This would help to enrich and deepen the research and increase its impact on important healthcare outcomes.

**Keywords.** Mixed methods research, qualitative and quantitative data, healthcare.

### **1. Introduction**

Healthcare work systems and processes are complex; understanding this complexity requires research that assesses the context in which people work and use technologies (Carayon, 2006; Dekker, 2012; Wilson, 2014). Therefore, research in human factors and ergonomics (HFE) aimed at complex sociotechnical systems such as those found in healthcare “should be carried out “in the wild” except for where ethical or substantial pragmatic issues intervene” (Wilson, 2014, p.7). This research should use multiple data collection methods to assess work situations and associated problems. This type of field research is known as “mixed methods research”.

After reviewing 19 definitions of mixed methods research, Johnson et al. (2007) proposed the following definition:

*“Mixed methods research is the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e.g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the broad purposes of breadth and depth of understanding and corroboration.”* (page 123)

This definition highlights the combination (or mixing) of different approaches at various stages of the research process. Mixing can occur at the stages of design, data collection, data analysis and interpretation (Creswell & Plano Clark, 2011). Mixing involves both qualitative and quantitative data that are collected with various methods,

such as observation, interview, focus group, survey, and archival methods. In this paper, we describe results of a systematic literature review on mixed methods studies in healthcare HFE.

## 2. Methods

Using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology (Moher, Liberati, Tetzlaff, & Altman, 2009), we conducted a systematic literature review of mixed methods research in healthcare HFE. We searched four databases (PubMed, PsycInfo, Web of Science, and Engineering Village) from their inception until February 2013. We identified 53 studies that were published in scientific journals and met the following inclusion criteria:

1. study in healthcare, i.e. the study included healthcare workers and professionals, or dealt with healthcare delivery issues.
2. HFE issues
3. mixing of qualitative and quantitative data.
4. For each study, we extracted information on the objective, setting, qualitative and quantitative data, mixed methods research design, stages of mixing, and HFE focus.

## 3. Results

The 53 studies addressed a range of HFE issues, such as usability of information technology, the work of nurses and physicians, and worker safety. Different strategies of mixed methods research have been defined (Creswell & Plano Clark, 2011). Table 1 provides information on five mixed methods research strategies that have been used in research on HFE in healthcare. These strategies collect qualitative and quantitative data concurrently (convergent parallel, embedded), sequentially (explanatory or exploratory sequential), or both (multiphase).

The most frequently used mixed methods study design in the 53 studies was convergent parallel. This includes two of our studies on the implementation of EHR (Electronic Health Record) technology in a small primary care clinic (Carayon, Smith, Hundt, Kuruchittham, & Li, 2009) and patient safety in outpatient surgery (Carayon, Hundt, Alvarado, Springman, & Ayoub, 2006). In the first study (Carayon et al., 2009), we evaluated the implementation of an EHR technology from different viewpoints (e.g., clinic staff, project management team) and, therefore, collected both qualitative and quantitative data using survey, work sampling and interviews. In the second study (Carayon et al., 2006), we used interview and survey to describe patient safety problems in the outpatient surgery process and to quantify frequency of problems as perceived by outpatient surgery staff. Hignett and her colleagues have also used the convergent parallel study design to assess safety culture related to patient handling (Hignett & Crumpton, 2007) and to identify HFE issues in ambulance design (Jones & Hignett, 2007). In addition, they have applied the exploratory sequential design to characterize risks of handling bariatric patients (Hignett & Griffiths, 2009).

Table 1 – Mixed Methods Study Designs Used in the 53 Studies

Study Design	Description	Number of Studies
Convergent parallel	Concurrent collection of qualitative and quantitative data with mixing of results during interpretation; often referred as triangulation	35 (66%)
Explanatory sequential	Collection of quantitative data followed by collection and analysis of qualitative data that builds on the results of the initial quantitative results	7 (13%)
Exploratory sequential	Collection of qualitative data followed by collection and analysis of quantitative data that builds on the results of the initial qualitative results	7 (13%)
Embedded	Additional collection of qualitative data within the primary quantitative design (e.g., interviews to interpret results of an experimental study) or additional collection of quantitative data within the primary qualitative design (e.g., case study)	2 (4%)
Multiphase	Combination of sequential and concurrent collection and analysis of qualitative and quantitative data over a period of time and within a major research program	2 (4%)

All 53 studies involved mixing of qualitative and quantitative data at the data interpretation stage. About one-third of the studies (34%) mixed qualitative and quantitative data at the data analysis stage. Forty percent of the studies mixed data at the collection stage. This often involved the use of the same data collection method (e.g., interview, survey) to collect both types of data. Only 7 studies involved mixing at the design stage. The study by Wolf et al. (2006) actually involved mixing at all stages of design, data collection, data analysis and interpretation. At the design stage, researchers were interested in combining a human factors engineering perspective with a nursing perspective. The human factors engineer focused her data collection on quantifying nurses' work, such as time spent on various tasks. The nurse researcher focused her data collection on characterizing the patient care stage of nursing activities. The two researchers collected data simultaneously. The quantitative and qualitative data were analyzed together to produce "cognitive pathways" of nursing work.

Methods to collect qualitative data most often involved interview (34 studies), survey (15) and observation (14). For quantitative data, the most frequently used methods were survey (34 studies) and observation (16 studies). Forty-two percent of the studies used a combination of interview for collecting qualitative data and survey for collecting quantitative data. A large number of studies used the same method for collecting both qualitative and quantitative data, such as survey (12 studies), interview (4) and observation (2).

#### 4. Discussion and Conclusion

Whereas we found a large number of studies with various mixed methods study

designs (53 studies), we encourage HFE researchers in healthcare to recognize the growing body of knowledge on mixed methods research (Creswell, 2009; Creswell & Plano Clark, 2011; Tashakkori & Teddlie, 2003, 2010). This will help in expanding the type of study designs used by HFE researchers. For instance, the majority of the 53 studies concurrently collect qualitative and quantitative data and then triangulate the various data sources at the interpretation stage; this is the convergent parallel study design. Other approaches are available to combine qualitative and quantitative data in innovative ways that can deepen and broaden our HFE understanding of complex healthcare work systems.

Sequential designs are often used in a two-step research approach where qualitative preliminary data are collected first; these data are then used to formalize hypotheses or to design quantitative data collection instruments. These two steps represent an exploratory sequential design. In the explanatory sequential design, research begins with a quantitative phase followed by a qualitative phase that can help to interpret results of the quantitative data analysis. The cycle or sequence of qualitative and quantitative data collection and analysis could continue for several steps; this is known as the multiphase study design. In our literature review, only 2 studies used the multiphase study design. This is probably a reflection of the challenge of publishing a large body of research within the constraints of scientific journals (e.g., word limit). Therefore, because our literature search only included papers published in scientific journals, we may have missed mixed methods studies with a multiphase design that are published in multiple outlets, including book chapters and reports. We encourage researchers to publish their mixed methods research in single papers in order to build the knowledge base and expertise in the application of mixed methods research applications to healthcare HFE.

Mixing of qualitative and quantitative data can occur at various stages of the research process, including data collection. In agreement with Asberg et al. (2011), we used the terms of qualitative and quantitative to describe data and not methods. A so-called 'qualitative' method such as interview can be used to collect quantitative data. Our literature review actually identified numerous studies that used the same method to collect both qualitative and quantitative data. Qualitative and quantitative data can also be mixed at the data analysis stage; this was done in 34% of the 53 studies. Mixing at the analysis stage involves a combination of the data, such as relating the qualitative and quantitative data in a matrix for comparison (Creswell & Plano Clark, 2011).

HFE researchers, in particular those interested in the healthcare domain, should become familiar and hopefully proficient at mixed methods research. We recommend that, instead of opposing the qualitative and quantitative strands of research, we should look for complementarity between the approaches and identify ways of mixing them. Each strand of research has its own unique set of scientific requirements (e.g., validity and reliability of measurement of quantitative data versus trustworthiness criteria for evaluating qualitative data) and methodological techniques (e.g., quantitative observation data collection versus semi-structured interview) that HFE researchers have to learn. Mixed methods research may actually represent an important path forward for HFE research as it brings together various traditions, methods and approaches that are necessary to assess, redesign and evaluate complex sociotechnical systems such as those found in healthcare.

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