Human Error Vulnerability Analysis in Healthcare: A Systematic Comparison of Methodologies

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Background: Many methodologies for Human Error Identification (HEI) have been proposed for healthcare, most of them having been adapted from aviation, manufacturing and nuclear power. However, the innate differences between these other domains and healthcare contribute to some of their shortcomings when applied to healthcare. An improved methodology is proposed in this paper.

Purpose of the Study: To compare the weaknesses and strengths of the currently used HEI methodologies and the proposed methodology.

Methodology: A team of three human factors engineers and one surgeon reviewed the Human Error, Human Reliability, and Medical Adverse Events literature to identify currently used methodologies for the identification of human and system errors in healthcare, and to identify their weaknesses and strengths. An improved and more robust methodology was developed and tested over a period of two years.

Results: Three major methodologies used in health care were identified: Health Failure Mode and Effect Analysis (HFMEA), Root Cause Analysis (RCA), and Systematic Human Error Reduction and Prediction Approach (SHERPA).

Three fundamental weaknesses were identified with these methodologies. First, they lack a standardized and precise graphical representation to illustrate the processes to be analyzed. HFMEA relies solely on simple process flow diagrams. RCA relies on graphical representation of factors that contributed to the accident after it happened. SHERPA relies on the widely used Hierarchical Task Analysis which provides a description of the task and goals performed, but lacks the ability to represent process flow. The proposed methodology uses IDEF0 (Figure 1) diagrams to represent both the hierarchical structure and the process flow of the activities to be analyzed. Strengths of IDEF0 are highlighted in Figure 2.

Second, they lack a comprehensive and systematic HEI technique. HFMEA does not provide any support for the identification of human error and their causes; instead it relies on the subjective recall of the people performing the analysis. RCA suffers from the same problem. SHERPA provides a limited taxonomy of human errors that consist of a limited bullet list of possible errors with no link to factors that contribute to them, nor consequences nor countermeasures for them. The proposed methodology provides an extensive taxonomy of human error which consists of a list of action verbs linked with possible human errors, also linked to the human vulnerability that leads to those types of errors and the countermeasures to prevent them (Figure 3).

Third, they lack the ability to accurately estimate criticality for the identified human errors. HFMEA uses subjective severity, occurrence and detectability estimates to compute a linear criticality score. RCA does not provide any methodology to estimate criticality of errors, and SHERPA uses experts' judgment. The proposed methodology

uses a score calculated based on a weighted combination of the severity, probability of occurrence, detection, and recovery.

Conclusions and Implications: The new methodology proves to offer significant improvement over the currently available methodologies (See figure 1). Methodologies like IDEF0 can contribute by providing a language to communicate among all stakeholders in the system and also by providing a framework to perform further systematic HEI analysis like the one described in this paper, in which biases and subjectivity from the analysts can be minimized.

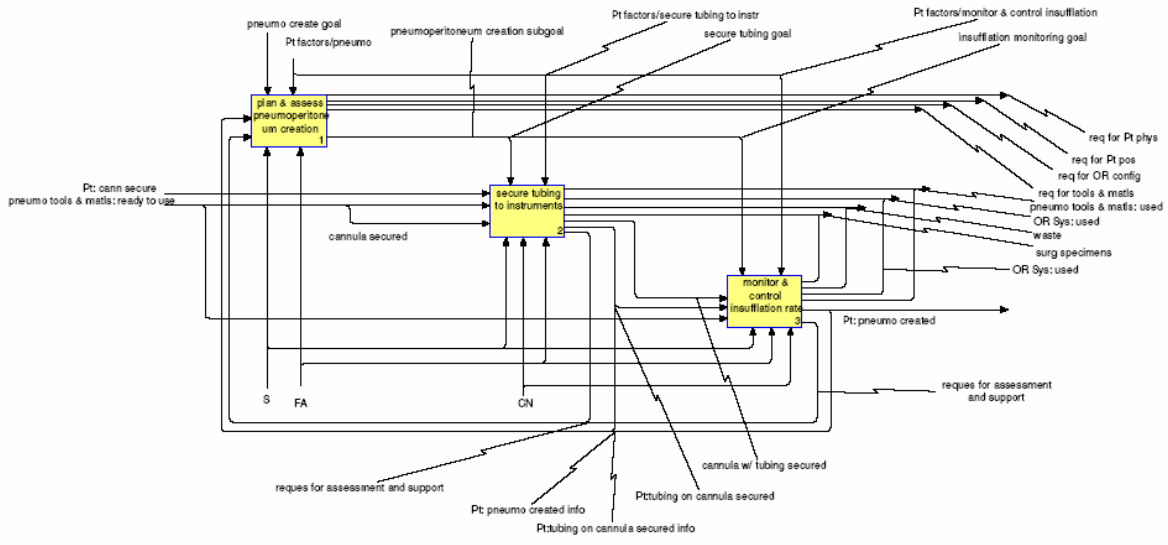

Figure 1 IDEF0 Diagram of the Pneumoperitoneum Creation Process

	HFMEA	RCA	SHERPA	New Methodology
Graphical Representation				
Tool Name	flow charts	decision trees	hierarchical task analysis	IDEF0
Goals diagramming	no	no	yes	yes
Process Flow	yes	no	yes	yes
Actors for Processes	no	no	no	yes
Process Constrains	no	no	no	yes
Process Inputs and Outputs	sometimes	sometimes	sometimes	yes
Human Error Identification				
Methodology	Expert Opinion	Expert Opinion	Taxonomy of Error and Experts Opinion	Taxonomy of Human Error
Objective	no	no	partially	yes
Systematic	sometimes	sometimes	yes	yes
Complete	no	no	sometimes	yes
Error classification	no	no	yes	yes
Error prediction	yes	no	yes	yes
Linkage between actions and errors	no	sometimes	sometimes	yes
Linkage between errors and human vulnerability	no	no	sometimes	yes
Linkage between human vulnerability and countermeasures	no	no	sometimes	yes
Electronic tools	no	sometimes	no	yes
Criticality Estimation				
Standardized Procedure	yes	sometimes	no	yes
Objective	yes	no	no	yes
Systematic	yes	no	yes	yes
Criticality Score	yes	yes	no	yes

Figure 2 Methodology comparison table. Strengths of the New Methodology

Stage	Verb	Object	Generic Error	Fallibility	Description
Build Group	Build	group	members resist team	limitations in training	The organization fails to fully embrace the team effort, trying to implement only certain aspects of the team concept (Tudor, Trumble, & Diaz, 1996: 35).
Think	Categorize	objects	incorrect mental model	representativeness heuristic	A rule of thumb by means of which we estimate the probability that an object (or event) belongs to a certain category based on how prototypical it is of that category, regardless of how common it actually is
Remember	Remember	information	fail to encode material in a manner that is intended	limitations in working memory	Working memory is limited in terms of space and capacity.(W&H p.248)
Communicate	Communicate with	group member(s)	fail to communicate within team	Excessive deference to position	When the social or organizational position of another team member prevents open and honest communication (W & H, 234).
Observe	Search	visual field	identifying the wrong letter	limited ability to distinguish similar letter structure	Symbols composed of features not grouped familiarly require more focal attention to process (W & H, 198).
Observe	Search	visual field	missing the letter	limited ability to distinguish similar letter structure	Symbols composed of features not grouped familiarly require more focal attention to process (W & H, 198).
Act	Turn	object	failure to turn to desire location	speed-accuracy trade-off, increase in index of difficulty	If the distance to the fix locatin increases or the width of the target decreases the index of difficulty for the movement increses, and this in turn increses the movement time for a fix accuracy. In the other hand if speed also increses give the above changes, accuracy is compromised. W & H p386. The information of the target location could be low and failure to identify the location can occur. W & H p49

Figure 3 Human Error and Vulnerability Taxonomy (small example)