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A Socio-Technical and Lean Approach Towards a Framework for Health Information Systems-Induced Error

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Abstract. The evaluation of Health Information Systems (HIS)-induced medication errors is crucial in efforts to understand its cause, impact and mitigation measures when trying to minimize errors and increase patient safety. A review of evaluation studies on HIS-induced medication errors was carried out, which indicated the need to further structure complex socio technical aspects of the subject. In order to satisfy this requirement, a new framework was introduced for the evaluation of HIS-induced error management in clinical settings. The proposed HO(P)T-fit framework (Human, Organization, Process and Technology-fit) was developed after critically appraising existing findings in HIS related evaluation studies. It also builds on previous models related to HIS evaluation, in particular, the HOT-fit (Human, Organization, Process and Technology-fit) framework, error model, business process management, Lean method, and medication workflow. HOPT-fit incorporates the concept of fit between the four factors. The framework has the potential to be used as a tool to conduct a structured, systematic, and comprehensive HIS evaluation.

Keywords. Medication error, management, evaluation, business process management, case study. Socio-technical, fit, Lean

1. Introduction

Health Information Systems (HIS) has become an integral part of global healthcare systems. Evaluation of these systems is essential to ensure the effective implementation and positive impact of HIS on healthcare delivery, including patient safety. HIS-induced errors have been highlighted as one of the most important topics in patient safety. More work on technology-induced errors is needed to understand it [1]. To evaluate the actual performance of any life-critical technology, detailed measures are required. Safety is part of a sociotechnical system as both people and clinical implementations contribute to the challenge of producing safer health care. Most unintended and hazardous effects of HIS come from socio-technical interactions [2].

Therefore, it is essential to understand the interaction between socio-technical issues related to the impact of HIS and patient safety. Borycki et al., [3] argued that integrated approaches based on cognitive and socio-technical aspects would enable interactions from a more holistic perspective between the two aspects and impact of HIS on clinical tasks in healthcare organizations. However, related studies are limited, yielding to huge knowledge gap in the two areas [2; 4].

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The paper reviews evaluation approaches for of HIS-induced errors and proposes a new framework for the evaluation of HIS-induced errors that incorporates comprehensive dimensions and measures of HIS effectiveness and the fit between the human, organization, process, and technology factors. This proposed framework in HOPT-fit (Human, Organization, Process and Technology-fit) would be potentially useful for conducting a structured and thorough evaluation study. It could also assist researchers and practitioners to unfold the complexity of HIS-induced error evaluation. The new framework is based on previous models on error evaluation, HIS evaluation, Business Process Management (BPM), and Lean methods. When developing this model, problems and methods related to HIS evaluation highlighted in the selected Health Informatics literature were discussed. Furthermore, the proposed model of HIS evaluation was presented to explore its applicability for improving current error models.

2. Theoretical Background

Patient safety can be improved or diminished based on how HIS is designed, implemented and applied [4]. HIS-induced errors are medical errors that are related to the overall stages of system development life cycle (SDLC) and HIS interactions with its socio-technical aspects [3]. Threats to patient safety include poor user-interface design, poor workflow and complex data interface. Adverse events could be caused by almost any interaction in the care system, at any time when providing care, and in all healthcare locations.

Evaluation approaches to technology-induced errors were developed based on different domains including technical, sociological, economic, human and organizational. Thus, a number of established and commonly used frameworks related to technology-induced errors were reviewed to identify the evaluation dimensions and measures (Table 1). The analysis showed that evaluation measures overlapped and complemented each other. In order to complement the four models, analysis was also conducted on related models and theories namely socio-technical [5], organizational change theory [6], clinical process management [2], and Lean method.

2.1. HOT-fit Framework

The HOT-fit evaluation framework [5] for HIS features comprehensive dimensions and measures of ‘technology’, ‘human’ and ‘organisation’ factors (Figure 1). Based on its comprehensive dimension, HOT-fit is not only used to evaluate HIS performance, efficiency, and its impact in various studies [5] but also systematically guide error evaluation according to the process phase and level of the three factors. Many HOT-fit measures overlap with those of technology-induced errors and human factor/ ergonomics [7], which can be structured systematically according to the HOT-fit framework.

Table 1. Selected error evaluation frameworks

	Reason's Model [8]	**The London Protocol [9]**	**Leape's Model [10]**	**Borycki's Model [2]**
Technology		Technology	Design missing aid/ manual Implementation Information availability Alerts, Reminders	Design Implementation simulation, testing
Human	Slip (attention) Lapse (memory) Mistakes (Rule-based, knowledge-based) Violation (routine, exceptional, sabotage)	Patient Individual (Staff) (knowledge & skills, health) Team (communication, supervision & help, structure)		Training
Organization	Working condition (e.g. poorly planned duty roaster, high workload, job training) Proactive risk management approach Error management: Limit the error Tolerate the error Holistic participation	Work environment (staffing, workload, equipment) Management (financial, structure, policy, standards, & goal safety culture & priorities (defence/ barriers) Context (economic & regulatory, external link)	Work setting: psychological precursors (stressful work condition) Management Job training Extent of error measurement Periodic data collection Evaluation Focus group Observation Chart review Simulation Reporting	Ongoing monitoring mechanism Error analysis Investigation protocol Risk management Collaborative teamwork Education Report system
Process	Design	Task design & structure clarity protocol test results decision-making aids	Design flaw unclear purposes & optimising method missing human principles: Alerts, Reminders	Workflow changes

3. Proposed Evaluation Framework

The proposed evaluation framework was developed after having critically appraised the findings of existing evaluation studies on HIS-induced errors. It also makes use of previous error models for categorizing evaluation factors, dimensions and measures. The HOT-fit framework was extended by upgrading selected evaluation measures to become evaluation factors and dimensions due to its significant contribution to error incidents and mitigation. The addition of the features is explained (Figure 1):

1. Process factors and its dimensions: Clinical stages, BPM, and Lean.
2. Error and mitigation measures in technological, human, organizational and process factors (structured list of error measures is under construction).
3. Dynamic "holes" in all four factors that represent latent and active failures. The holes are prone to hazards when they are aligned together. In contrast, if the following layer can defeat the flaw of the previous defence layer,

hazards can be avoided as they are diverted away, instead of passing through the whole system.

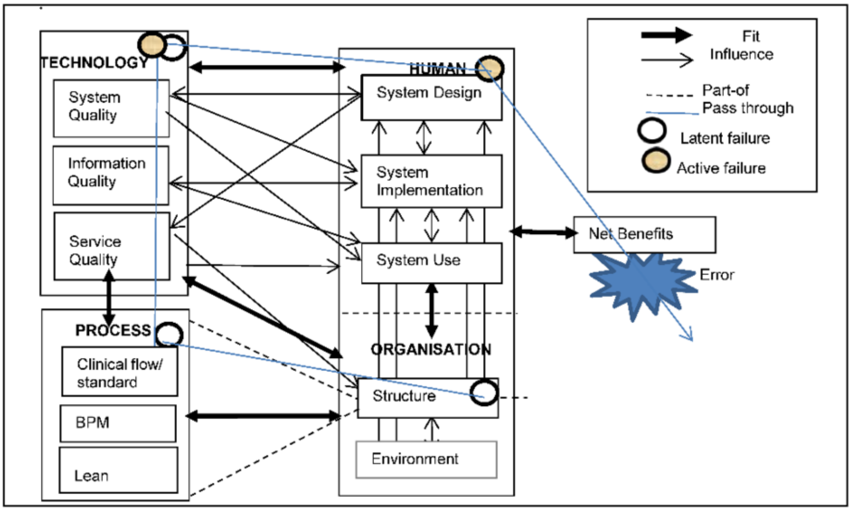

Figure 1. Human-Organization-Technology-Process Fit (HOPT-fit) Framework

The four factors and the effects by HIS correspond twelve interrelated dimensions of HIS success: System Quality (measures of the information processing system itself), Information Quality (measures of IS output), Service Quality (measures of technical support or service), System Development (processes and issues in a SDLC), System Use (recipient's consumption of IS output), User Satisfaction (recipient's response to System Use), Organisational Structure, Organisational Environment, Process and Net Benefits (overall IS impact that include HIS-induced errors). As part of the organizational element, process is featured as one of the factors and this encapsulation is represented using the dashed line (Figure 1) that links process and organization. Process is central to error failure and management because errors are commonly triggered during the execution of a process. This study proposed three dimensions for process, namely the clinical stages, BPM life cycle, and quality thinking using Lean methods. As the study focused on medication errors, it examined medication stages and its compliance to the 5 rights as in right drug, dose, route, time, and patient. Process management can be assessed according to various stages of BPM, whilst process quality and safety can be examined using Lean methods which have proven to improve clinical outcomes, enhance patient safety and reduce error [11]. The fit concept between technology, human, organisation and process is complex, subjective and abstract [5].

4. Conclusions

This paper has identified the problems, reviewed the existing methods and proposed a new evaluation framework for HIS-induced errors. In the search for an appropriate, comprehensive approach to evaluation, a number of existing frameworks for IS error models in Health Informatics were analysed. The review suggests that there is a need to improve existing HIS evaluation methods. The strengths and limitations of these frameworks were discussed and used as a basis for the new proposed framework, namely the HOPT-fit. In addition to the literature review, this framework builds on the HOT-fit framework, the Leavitt Model, previous error models, BPM, and Lean methods. In order to validate its usefulness, this framework needs to be tested in clinical settings. Findings from the fieldwork could be used for further improving and refining this framework. The framework should be applied flexibly, depending on different contexts and purposes; emphasis should be given on the most important dimensions and measures.

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