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Process Approach for Managing Health Information System-Induced Medication Errors

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Abstract. Health information systems (HIS) and clinical workflows generate medication errors that affect the quality of patient care. The rigorous evaluation of the medication process's error risk, control, and impact on clinical practice enable the understanding of latent and active factors that contribute to HIS-induced errors. This paper reports the preliminary findings of an evaluation case study of a 1000-bed Japanese secondary care teaching hospital using observation, interview, and document analysis methods. Findings were analysed from a process perspective by adopting a recently introduced framework known as Human, Organisation, Process, and Technology-fit. Process factors influencing risk in medication errors include template- and calendar-based systems, intuitive design, barcode check, ease of use, alert, policy, systematic task organisation, and safety culture Approaches for managing medication errors also exert an important role on error reduction and clinical workflow.

Keywords. Medication error, health information systems, evaluation, workflow, lean, case study

1. Introduction

Despite the potential of health information systems (HIS) in reducing medication errors, HIS have been associated with new types of medication errors [1]. This paradox is primarily attributed to HIS misfit with the work patterns and settings of health care, resulting in the inefficient use and unintended impact of HIS in error reduction. The prevalence of HIS adoption and safe application remains at its infancy due to technical and organisational challenges [2, 3]. Further research is required on work organisation problems, cooperative work problem [2] and identifying safe practices for managing information technology (IT) transition. A close look at clinical process management can demonstrate the overall process, its specific steps in identifying the control mechanism and error risk and its impact pertinent to HIS-induced errors. This paper reports the preliminary findings of a case study on the management of HIS-induced medication errors from a process perspective in clinical practice.

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2. Theoretical background

The proposed Human, Organisation, Process and Technology-fit (HOPT-fit) evaluation framework was developed after critically appraising the literature [4]. Previous error models were also used to categorise evaluation factors, dimensions and measures. As an organisational element, process is featured as one of the factors and is represented as the dashed line that links process and organisation in Figure 1. Process plays a central role in error failure and management because errors are commonly triggered during the execution of a process. The developed framework proposed three dimensions of process: the clinical stages, business process management (BPM) life cycle and lean methods. This study focused on medication errors; thus, it examined the stages of medication and its compliance with the five rights: right drug, dose, route, time and patient (5R). Process management can be assessed in accordance with various stages of BPM. Meanwhile, process quality and safety can be examined using various lean tools and methods.

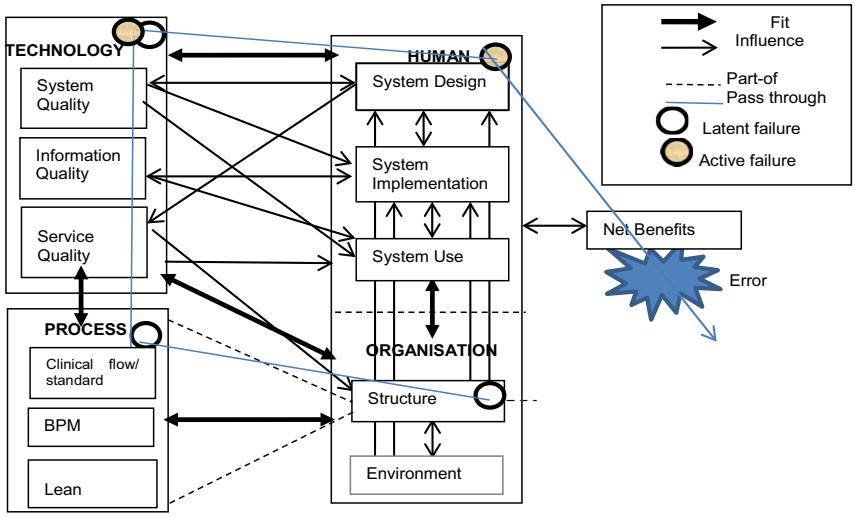

Figure 1. HOPT-fit framework (adapted from [4]).

3. Method

A summative case study evaluation was conducted in actual clinical settings to explore the context and nature of the event to be investigated. Data were gathered using interview, observation and document/artefact analysis. We studied a number of HIS in a 1000-bed Japanese secondary care teaching hospital (SCTH). Face-to-face and written interviews were audio- and manually recorded and then transcribed in English and Japanese by translators. Using a purposeful snowball sampling method, 13 informants among clinicians and management committee were interviewed. Four techniques were used to analyse the results: coding, analytic memos, contextual analysis and narrative analysis. To understand medication error management holistically, data were analysed using process approaches [5, 6]: 1) Major medication processes in an end-to-end clinical process were identified and structured into five sub processes, from prescribing to monitoring. 2) A process step table was constructed; it includes process information flows and owners. 3) Process error risks were summarised, and their sources (input,

process or output flaws) and subsequent impact were identified. 4) Activities that serve as preventive, detective or corrective controls were determined.

4. Results

Medication use (MU) for the SCTH's inpatients was documented using a process step table that featured the medication process, control, flaw, and impact. MU steps were identified based on the MU process for hospital and long-term cases [7]. The SCTH additional processes is nearly double the number of those of MU. The selected steps, error control, flaw and impact are provided in Table 1. The medication process for the STCH inpatients involved several HIS, and a safety measure is implemented on every possible point of care. The doctor *prescribe*s medicine in the consultation room using a computerised provider order entry (CPOE). The medication order is sent to the pharmacy department for drug preparation. The doctor gives order instructions to the nurse through a calendar, template-based instruction system (InstS). The nurse receives the instruction. The doctor checks whether the nurse has seen the instruction (indicated by a changed coloured display). The nurse sees the new doctor's instructions that are highlighted in different colour. When the nurse checks it, he/she can post questions to the doctor or clicks the 'received button' to confirm the receipt of the doctor's instruction. The pharmacist checks the order data on Pharmacy IS (PhIS), downloads the data to PhIS, prepares the drug envelope and sends the envelope and drug to the nurse station for dispensing the medication to the address entered in a mechanical cart. The nurse delivers the envelope to the ward for administration. STCH policy requires the preparation of a one-dose package to avoid confusion.

Changes in the doctor's order are designed with error control but are still prone to errors. Error risk may occur when the doctor changes the order but the nurses are unaware of it because they do not always check the system. Therefore, the system should ensure that nurses are informed about changes. If the doctor changes instructions before a drug is mixed, then the nurse will print the mixing sheet with a new bar code. Otherwise, if the nurses check the old mixing sheet bar code against the new bar code update in the system, then an error alert is prompted due to bar code mismatch. Similarly, if a change is made after an order is sent to the pharmacy, then the pharmacy does not know about the change. The drug may already be delivered but administration should be stopped. The instruction system is updated with the change and the medicine should be returned to the pharmacy. The new mixing sheet is printed out. The information in the pharmacy system is only updated if drug quantity increases.

5. Discussion

The current study adopted the core processes and adapted them to MU processes that are unique to the SCTH setting. The process model is beneficial for modelling the overall process, ensuring the inclusion of basic processes and arranging them in a structured and systematic manner. Breaking down the process to the simplest task unit enabled the discovery of process variance, barrier, error risk, and fit with HIS that are otherwise overlooked in the SOP. The process of determining step breakdown and classifying it as either a step or control, a single or a sub step is challenging. Optional activities are

explicitly modelled due to their intuitive manner and positive influence on 'the structural complexity and the understanding of the process flow' [8].

Table 1. Selected medication process, control, risks and impact

Process steps [resource(s)]	Control and impact	Error risk and impact
Prescribing		
P1.1 Make clinical decisions	Calendar-based interface, graphical symbol and colour - AL	Overlapping medication - VACT
P1.2 Select drug		
P1.3 Determine drug regimen	Automated dosing and calculation – ACT; Alert - A	Alert override - ART Excessive alert - R
P1.6 Stamp prescription	Identity authentication - V	
P1.7 Submit order	Daily-based drug - AT	
P1.8 [O] Change order	Must cancel previous order - A	Incomplete changes - VAT
P1.9[O] Submit order change		
Instructing		
I2.1 Send instruction	Template, calendar-based interface-L; Timing-based drug - LT	
I2.7 Check if order is received	Automated colour-coded change - LAT	
12.8 [O] Send change order instruction	Prevent instruction overlap – VAT; Change message – ALT; View nurse check - AT Highlights in MD interface - LT	Nurse does not check changes – VACT; Nurse forgets to exclude stopped medication or include added medication - VACT
I2.8 [O] Check seen changes	Disappeared highlights	
Transcribing		
T3.1 Check order data	Correctness check: IF before Ph. check → THEN OK; IF after Ph. check → THEN error - VAT Automated colour-code change - L	Change is made after order is sent to PhIS and drug is prepared - VACT
T3.2 Download data to PhIS		
Dispensing	SOP - VACT	
D4.1 Enter and screen data		
D4.2 Prepare drug envelope	Completeness of patient and drug information - VACT	
D4.3 Prepare, mix and compound drug	5R, patient-drug bar code match: IF before drug mix → THEN OK IF after drug mix → THEN error message – VACT Prepare one-dose package - AT Two independent nurse checks - VA	Error can occur if the system is not checked before injection drug mixing - AT
D4.4 Dispense to nurse station	Dispensing and cart machine - AT	
D4.5 Dispense to ward		
Administering		
A5.3 Nurse verifies order	5R, patient-drug barcode match: IF match, THEN OK; IF mismatch, THEN prompts error alert- VACT	Nurse does not check the system or use the barcode before administering - VACT
A5.4 Administer drug	Colour code for taken, delivered and undelivered drugs -VACT	Nurse forgets to take out stopped drug or add new drug - VACT

Notes: Italicised step = unique to SCTH Ph. = pharmacy; 5R = 5 rights; Data quality measures: validity (V), accuracy (A), timeliness (T), completeness (C), relevancy (R), legibility (L)

STCH has established various controls to ensure patient safety including intuitive design using template, calendar, and automated functions. However, several controls are

also error-prone. Subsequent flaws that penetrate through the aligned control mechanisms from all four HOPT factors will result in an error incident. By contrast, several error risks have no control mechanism. Continuous monitoring and evaluation through lessons learned can improve HIS development and use, fitting it with the clinical process to prevent recurring errors. In addition, safety culture and Japanese Kaizen approach, which focuses on continuous incremental improvement, has been proven to yield significant results over time in STCH.

Although the study was conducted at specific, clinical settings of one hospital over a short duration, the data were collected rigorously and systematically, yielding to in-depth findings that are also applicable to other clinical contexts. Additional feedback was obtained from the participants to clarify and gain more information.

6. Conclusions

Every process step is prone to errors, but several steps have a control mechanism to prevent or minimize error. Human intervention is still required in tandem with system intervention to avoid errors. The case study findings also demonstrate the feasibility of the process approach to address process as one of the essential components of IS, and the fit between the HOPT factors. This evaluation approach is potentially useful to researchers and practitioners for conducting rigorous evaluation studies. Lessons can be learned from this study's findings and recommendations for improving HIS development and process management can be identified to guide the future development of HIS, increasing its effectiveness and improving patient safety.

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