

Enhancing CDSS Alert Appropriateness in Clinical Workflow Using the Lean Method

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Abstract. Despite the widespread use of clinical decision support systems with its alert function, there has been an increase in medical errors, adverse events as well as issues regarding patient safety, quality and efficiency. The appropriateness of CDSS must be properly evaluated by ensuring that CDSS provides clinicians with useful information at the point of care. Inefficient clinical workflow affects clinical processes; hence, it is necessary to identify processes in the healthcare system that affect provider's workflow. The Lean method was used to eliminate waste (non-value added) activities that affect the appropriate use of CDSS. Ohno's seven waste model was used to categorize waste in the context of healthcare and information technology.

Keywords. Lean, CDSS, Clinical workflows, Evaluation, Patient safety, Ohno, healthcare

1. Introduction

Over the past few years a huge number of HIS, such as CDSS and electronic health records (EHR), have been implemented and widely adopted in healthcare settings. HIS has vast potential in reducing medical errors; however, HIS can also incur new types of risks that can lead to patient and medical harm [1]. CDSS can improve a clinician's decision by providing guidelines for the clinician. For example, CDSS alerts assist clinicians by notifying them of adverse events and contradictions [2]. One of the safety concerns regarding CDSS is "alert fatigue"[3], where clinicians ignore high volumes of alerts that could lead to adverse events or medication errors [3]. The introduction of CDSS in healthcare has created additional workload and caused unfavorable workflow through inefficiencies and disruptions in the clinical process.

The limitations of CDSS in relation to supporting care coordination and routine clinical work, such as prescribing medication and alert fatigue, is widely debated [4]. With the wide range of clinical tasks carried out in the healthcare system, having information available in a consumable manner at the right time during clinical processes is critical. Identifying clinical processes that do not fit with clinical workflows is the first step required for the successful implementation of CDSS. Healthcare consist of a series of inter-related processes. Care coordination is a matter of properly aligning and

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synchronizing clinical processes [5]. CDSS alerts must align and fit the multiple dimensions of healthcare processes, while avoiding the disruption of clinical workflows [2]. The introduction of CDSS, with its alert functions, has led to serious workflow issues. The Lean method is one of the tools used to identify processes in the healthcare system that affect the clinician's workflow [5][6]. A literature review was carried out on studies extracted from databases such as PubMed, Scopus, Google Scholar, Medline and ISI Web of Knowledge using these terms: CDSS, alert fatigue, alert override, Lean, Waste, and HIS. Other sources included citation chaining, web search engines and textbooks. Ohno's seven waste models for classifying waste in manufacturing was identified and applied to classify waste associated with the use of CDSS.

2. CDSS alert appropriateness

CDSS must address the challenges of providing information at the appropriate time in an understandable format during clinical processes. Hence, there is a need to apply methods that enhance the appropriateness of CDSS alerts. Evaluation helps to provide answers to CDSS alert appropriateness issues and its effect on patient safety in healthcare. A well-designed CDSS alert system improves a clinician's decision-making as well as task performance. In contrast, a poorly designed CDSS system distracts clinicians and reduces performance. Designing alerts that are non-interruptive reduces alert fatigue and also decreases or reduces interruptions during the provider's workflows [4]. Hence, a proper understanding of workflow issues that affect alert appropriateness must be explored. Appropriateness can be defined as CDSS alerts presented to its users in the right context, providing patient-specific information during the workflow, less intrusive displays on the screen in languages that users understand as well as displaying correct and useful information about a patient. Successful workflow integration must carefully consider how CDSS alerts are triggered during patient interaction [2]. CDSS tools have been found to be time-consuming and disrupt the physician's workflows, leading to the lack of system acceptance among physicians. Inappropriate alert presentation in the work process distracts clinicians [7]. One example of an effective utilization is reported on an EHR, which is capable of integrating the computerized provider order entry (CPOE) with CDSS, which supports clinical workflows and facilitates clinical outcome objectives [8].

3. Lean in Healthcare

The redesigning of clinical healthcare processes is a result of medical errors and adverse events that are attributed to the wide use of electronic medical records. One of the common methods used during process redesigning is Lean thinking [5]. Lean was first introduced by Womack and Jones [9] with the aim of improving operational practices of Japanese automotive manufacturers, known as the Toyota Production Systems (TPS). Lean creates a culture of continuously improving processes by using tools that eliminate waste and unnecessary actions aimed at creating value [6]. Lean adopts a large set of tools such as A3 and value stream mapping (VSM) to improve clinical processes [5]. VSM is used to visualize information and the physical flow of a process. A3 is a structured document with a standardized format for solving problems and making it easier for clinicians and staff to review them. Generating a value stream map is the first

step towards understanding how processes work and help to identify value and waste from a customer’s perspective. The Lean method that uses VSM and A3 tools could identify waste in critical information systems and optimize process flow [5]. Other Lean tools, such as root cause analysis, Kaizen, and 5S, are used to identify waste and improve clinical workflows in healthcare. The application of Lean in healthcare improves patient satisfaction through improved actions and processes [5][6]. For example, a pharmacy department applied Lean principles for reducing waste and improving workflows, which led to a reduction in missing doses, decreased medication errors, reduced patient-specific waste and improved time/delivery of medication [10]. Healthcare organizations must devise creative means to survive by putting in place ways to deliver quality care that produces value-added activities. Wastes are categorized as defects, motion, transportation, over-processing, overproduction, inventory, motion, and waiting [11].

3.1. Lean and CDSS alert appropriateness

CDSS appropriateness is affected by workflow issues, while inefficient workflow intrusions affect patient safety and increase the overall cost of healthcare [12]. The CDSS alert function must support clinical processes and help achieve organizational goals. Clinical workflow in healthcare affects CDSS adoption, safety, quality, efficiency, and effectiveness of care delivery. In more general terms, it is arguable that the principles of Lean thinking, particularly the removal of waste and pursuit of perfection, can be applied to any system where the product flow meets the demand of customers, users or consumers [13]. The efficiency of a CPOE with orders set in a hospital had improved by using root cause analysis to identify challenges in using the system, which resulted in increased quality of orders and subsequent quality of care [14]. The root cause analysis method was used to identify causes of alert fatigue, which led to 13% reduction in false alarms during clinical care [15]. Lean six sigma was used to reduce alert fatigue in an electronic prescribing system, which reduced false positive alerts by 25%, thereby improving the quality of care [16]. Lean can be used to improve the effectiveness of CDSS alerts in healthcare and enhance appropriateness of CDSS alerts. Enhancing the appropriateness of CDSS alerts using Lean intervention requires CDSS to support clinical processes. The practice of Lean in healthcare has produced positive outcomes [5]. Table 1 shows an overview of waste in manufacturing and CDSS using the seven waste models [11].

Table 1. Overview of waste in manufacturing and CDSS

Waste type (Ohno’s seven models)	Manufacturing	CDSS
Transportation	Unnecessary workarounds in the factory due to inefficient factory layout and use of building materials	Alert triggering at an inappropriate time during patient care leads to workarounds of clinicians in the healthcare system. [8]
Inventory	Inventory waste is concerned with excess raw materials or information that is not used	CDSS alert that is very intrusive, displaying so much information making it difficult for clinicians to process all the information. [2]
Defects	Finished goods or services that do not conform to customers specification resulting in dissatisfied customers.	Alert displaying erroneous information because of poor CDSS design, as this impedes the clinician’s performance undermining patient safety. [17][7]

Over production	Producing more than what is required or needed, which leads to excessive waste of inventory	CDSS generates excessive alerts (e.g. nuisance alerts, false alerts) resulting in alert fatigue and override of relevant and irrelevant alerts. [3]
Over processing	Carrying out unnecessary work that does not add value to customers	Clinicians spend more time responding to alerts and neglecting patients, which undermines patient safety. [7]
Waiting	Waiting for an action before a task can be completed (machine downtime, waiting for delivery of new batch etc.)	Clinicians waiting for CDSS alerts to notify them of adverse events before they can complete a task. [16]
Motion	Human movement that is unnecessary for completing a task	Clinicians log in to multiple screens separately, switching between a different path on the screen when using CDSS alerts. [18]

4. Discussion

The use of CDSS in healthcare causes workflows that affect a clinician's performance, resulting in adverse events. Most workflows in hospitals amount to waste and have a negative effect on patient safety. This study specifically used the original waste concept defined by Ohno and explored categories of waste that affect CDSS appropriateness, as shown above. Poor alignment of CDSS and clinical workflows had led to unreliable clinical processes and workarounds. Workflows negatively influence the efficiency of delivering goods or services to healthcare customers. An understanding of how, why and where workflows occur in CDSS is necessary for improving clinical processes and preventing medical errors. The Lean method provides a more focused approach for continuously improving clinical processes by using a variety of tools and methods [5]. Hence, this study could help inform researchers regarding the application of the Lean method for resolving other issues that affect the appropriateness of CDSS.

5. Conclusion

Understanding waste in the context of HIS is necessary for the transformation of healthcare. This paper explored and applied Ohno's concept in the healthcare domain to enhance the appropriateness of CDSS and its alert function. Ohno's concept was originally applied in the manufacturing system. With the use of Lean, this study was able to identify inefficient workflows affecting the use of CDSS and its alert function in healthcare. Future studies should focus on applying the Lean method to CDSS using tools such as VSM and A3 to redesign clinical processes, as this will enhance clinical workflows and improve alert effectiveness.

Acknowledgement

We gratefully acknowledge the funding received from the Universiti Kebangsaan Malaysia (National University of Malaysia) from the Grand Publication Impact Grant (DIP 2016-033) that helped sponsor this study.

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