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Impact of a clinical decision support system for high-alert medications on the prevention of prescription errors

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ABSTRACT

Objective: To evaluate the impact of a high-alert medication clinical decision support system called HARMLESS on point-of-order entry errors in a tertiary hospital.
Method: HARMLESS was designed to provide three kinds of interventions for five high-alert medications: clinical knowledge support, pop-ups for erroneous orders that block the order or provide a warning, and order recommendations. The impact of this program on prescription order was evaluated by comparing the orders in 6 month periods before and after implementing the program, by analyzing the intervention log data, and by checking for order pattern changes.
Result: During the entire evaluation period, there were 357,417 orders and 5233 logs. After HARMLESS deployment, orders that omitted dilution fluids and exceeded the maximum dose dropped from 12,878 and 214 cases to 0 and 9 cases, respectively. The latter nine cases were unexpected, but after the responsible programming error was corrected, there were no further such cases. If all blocking interventions were seen as errors that were prevented, this meant that 4137 errors (3584 of which were 'dilution fluid omitted' errors) were prevented over the 6-month post-deployment period. There were some unexpected order pattern changes after deployment and several unexpected errors emerged, including intramuscular or intravenous push orders for potassium chloride (although a case review revealed that the drug was not actually administered via these methods) and an increase in pro re nata (PRN; administer when required) orders for most drugs.

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Conclusion: HARMLESS effectively implemented blocking interventions but was associated with the emergence of unexpected errors. After a program is deployed, it must be monitored and subjected to data analysis to fix bugs and prevent the emergence of new error types.

1. Introduction

High-alert medications (HAMs) are medications that are more likely to cause significant harm to the patient than other medications [1–8]. This means that if there is an error in the use of HAMs, the outcome for the patient could be catastrophic [1,2,8]. Indeed, HAMs are well-known causative agents of the majority of critical adverse drug events (ADEs): more than 50% of all ADEs relate to these drugs [7,9]. Typical examples of HAMs are high concentrations of potassium chloride (KCl), regular insulin (RI), and anticoagulants. The Institute for Safe Medication Practices updates a list of HAMs in consultation with practicing healthcare professionals to create awareness of their dangers [6]. Other interventions that aim to prevent HAM-related errors have also been introduced, including the 5-Million Lives Campaign in the United States, the standardization of HAM-handling protocols or processes, the development of standard order sets, the introduction of standard concentrations, and the use of barcode technology [2,10–15].

Since the Institute of Medicine in the United States found that health information technology can effectively improve patient safety, especially in terms of reducing HAM-related ADEs, clinical decision support systems (CDSSs) have also been developed and implemented [16–19]. In general, CDSSs can help healthcare providers by providing clinical information and warnings regarding drug-drug interactions, monitoring ADEs, and supporting decision-making based on clinical practice guidelines [20–22]. Several CDSS projects have revealed that these systems reduce ADEs [15], decrease medication error rates [19], and reduce cost [23]. However, most CDSSs focus on particular drugs such as warfarin and insulin; they do not deal with HAMs themselves as a drug category. To reduce HAM-related errors at an institutional level, a CDSS that specifically targets all HAM use and provides diverse interventions is needed.

The present study aimed to evaluate the impact of a HAM-focused CDSS that is called HARMLESS (high-alert-medication recognition and management system to lower errors and to secure safety). It was developed to reduce HAM-related errors by providing several supporting, warning, and blocking interventions. The present study is an analysis of its results after it was applied to a home-grown computerized physician order entry system (CPOE) in a tertiary teaching hospital.

2. Methods

2.1. *Development of HARMLESS*

The goal of HARMLESS was to reduce HAM-related errors and improve patient safety in Asan Medical Centre (AMC). AMC is the Korea's largest acute care hospital with about 2700 inpatient beds and 11,000 outpatient visits per day. Over 1500 doctors use AMC medical information system that is a homegrown and integrated system providing electronic medical records, CPOE, PACS, etc. for clinical practices and researches [24]. The HARMLESS development was divided into two phases, namely, the determination of the solutions that would form the basis of HARMLESS (phase 1) followed by the development of the HARMLESS program itself (phase 2).

In phase 1, the HARMLESS task force team (TFT) was established. This multidisciplinary team was composed of performance improvement (PI) experts, a medical informatician, clinical pharmacists and registered nurses, and it reviewed a list of HAMs suggested by the literature and TFT members. The clinical processes from prescription order through to medication administration (including dispensing) were also reviewed. Potential errors and their causes were identified, and new processes that were not even possible at that time were suggested. Thereafter, the TFT derived the HARMLESS solution, namely, the improvement scheme that aimed to prevent these potential errors.

In phase 2, the interventions in the HARMLESS solution that could be computerized were selected and the HARMLESS program was developed. The program was then added to the CPOE of AMC and used to improve the use of five typical HAMs, namely, RI, KCl, warfarin, heparin, and urokinase [24]. These drugs were selected because errors are made with them frequently, such errors can have severe effects, and all were the subject of recent error reports. HARMLESS provided both drug-common and -specific interventions. The overall objective was to first assess this intervention frame for the five HAMs at the AMC and then use HARMLESS with all HAMs.

The prototype HARMLESS program largely provides three types of functions (Table 1). The first is to provide the clinicians and nurses with HAM-related clinical knowledge, namely, the types of frequent errors and key messages which should be considered when prescribing an order, disease-specific order protocols of clinical departments, and general drug information (e.g., the usual dosage, side effects, and pharmacodynamics of the drug). This knowledge was synthesized by the TFT members, including the PI experts, after they reviewed HAMs related clinical knowledge from various sources, and it is transmitted via HARMLESS to the clinician using the CPOE as follows. As shown in Fig. 1, on the CPOE window, the HAMs icon (red circle containing a white exclamation mark) is displayed just in front of the drug code. When the mouse arrow hovers above the icon, a "frequent errors" or "key warning" message is displayed. Moreover, when the HAMs icon is double-clicked, the clinicians obtain HTML documents that contain clinical information.

The second HARMLESS function is to produce a pop-up when erroneous orders are prescribed, which include