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Implementing smart pump technology in a pediatric intensive care unit: A cost-effective approach

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ABSTRACT

Objective: To analyze the cost effectiveness of implementing smart infusion pump technology in a pediatric intensive care unit (PICU).

Material and methods: An observational, prospective, intervention study with analytical components was carried out. A drug library was developed and integrated into the Carefusion Alaris Guardrails® infusion systems. A systematic analysis of all the data stored on the devices during use was performed by the data processing program Guardrails® CQI v4.1 Event Reporter. Intercepted errors were classified in terms of their potential severity and probability of causing an adverse effect (PAE) had they reached the patient. Knowing the estimated cost of a preventable adverse effect (AE), we analyzed costs saved and the profit/cost ratio resulting from the implementation process.

Results: Compliance with the drug library was 92% and during the study period 92 infusion-related programming errors were intercepted, leading to a saving of 172,279 euros by preventing AEs. This means that 2.15 euros would be obtained for each euro invested in hiring a pharmacist to implement this technology.

Discussion: The high percentage of use of safety software in our study compared to others allowed for the interception of 92 errors. The estimation of the potential impact of these errors is based on clinical judgment. The cost saved might be underestimated because the cost of an AE is usually higher in pediatrics, indirect and intangible costs were not considered and pharmacists involved do not spend the whole day on this task.

Conclusions: Smart pumps have shown to be profitable in a PICU because they have the ability to intercept potentially serious medication errors and reduce costs associated with such errors.

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1. Introduction

The growing complexity of the so-called "drug utilization circuit" carries an increasingly high risk of medication errors occurring at the different stages involved from prescription to administration [1,2].

Medication errors are usually the result of failures during the medication process and may or may not result in patient harm. Almost all medication errors are considered to be preventable [3].

Potential adverse events are "medication errors that could have caused injury, but did not, either because of chance or because they were intercepted before reaching the patient".

In general, the incidence of preventable adverse events, considered as medication errors, is high and the severity of these is greater than in non-preventable adverse events [4].

Errors that occur in the administration phase are the hardest to intercept [2], and their impact depends on the route of administration, type of drug and patient characteristics [5–9]. Therefore, ensuring the safe handling of high-risk drugs and those with a narrow therapeutic window that are administered intravenously to critically ill pediatric patients should be a priority in our healthcare setting.

The development and implementation of new technologies, such as smart infusion pumps, can help increase safety in intravenous drug administration that requires strict infusion rate control [10].

A smart pump is a conventional infusion pump with an integrated drug library. Each drug in the library has programmed concentrations, dosage units and maximum and minimum infusion rates. Based on these parameters, the so-called hard and soft limits for upper (UHL, USL) and lower (LHL, LSL) limits, can be defined with the aim of preventing over- and under-dosage, respectively [10]. If a user attempts to exceed the defined dose for a soft limit by mistake, an alarm will sound to alert the user that the dosage or rate of administration may not be right for a particular patient, although it allows the infusion to continue at the same dose or rate, once the alarm has been acknowledged. By contrast, accidentally exceeding a hard limit will sound an alarm, leading the user to cancel the infusion or reprogram administration.

Different institutions acknowledge the benefits of this technology and conventional systems are gradually being replaced by smart systems [11,12]. However, few articles have been published about the real impact of these systems on intercepting infusion-related programming errors and cost savings [13], and so further studies are needed to help clarify how cost-effective this tool is in the health setting.

2. Objectives

To analyze the cost-effectiveness of implementing smart infusion pump technology in the intravenous drug administration phase in a Paediatric Intensive Care Unit (PICU), in terms of costs of investing in this technology and costs saved by intercepting infusion-related programming errors.

3. Materials and methods

3.1. Setting

A study was conducted at the PICU at Hospital General Universitario Gregorio Marañón, Madrid, on the prevalence of infusion-related programming errors with smart pumps. It ran from 18 January 2010 to 20 June 2011.

The maternal and children's hospital has a total of 223 beds, 140 of which are for pediatric care and 83 for obstetrics and gynecology, distributed over 5 floors of the hospital. The hospital operates an electronic prescription program with 18 automatic dispensing systems.

The PICU has 11 beds and approximately 500 admissions per year. 35% of patients have cardiac disease, including post-operative care following heart surgery, 30% are post-operative patients following other surgery and the remaining 35% are medical patients. The nurse/patient ratio is 1:1.

3.2. Drug library development and implementation

A multidisciplinary team was set up with two intensive care pediatricians, two clinical pharmacists and the PICU nurse supervisor. The team members took an active part at each stage of the implementation process. One of the pharmacists was responsible for leading the whole process as well as coordinating the tasks of the team.

During the seven months prior to the error interception study – June to December 2009 – the first version of the drug library was drawn up and integrated in the CareFusion Alaris Guardrails® infusion systems that were already available at the hospital at the time of the study.

The data processing program Guardrails® CQI v4.1 Event Reporter performed a systematic analysis of all the data stored on the devices during routine clinical practice. This meant that, first, the drug library could be improved throughout the study, producing different versions that could be updated periodically and integrated in the system [14] thus helping to perfect the technology overall [15]. Second, we were able to determine the total number of infusion-related programming errors prevented by the different alerts triggered by the safety software.

Because infusions could be started with or without the drug library, the percentage of compliance with the drug library was defined as the number of infusions programmed through the safety software per 100 infusions started.

3.3. Error analysis

Having identified the errors intercepted after implementing the technology, they were then classified by their potential severity and the probability of causing an adverse event (PAE) in the patient if the error had reached him/her.

Based on our self reporting system we could also analyze whether or not errors related to the use of infusion pumps actually reached the patients.

A group of four clinical pharmacists with extensive experience in pediatrics and medication errors and another group of four intensive care pediatricians in the PICU independently