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Technologies to Reduce Errors in Dispensing and Administration of Medication in Hospitals: Clinical and Economic Analyses

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Introduction

Because there are many steps required in the preparation of medications for hospitalized patients, there are greater opportunities for errors. Most medication errors are minor, but some may result in an adverse drug event. A Canadian study reported that 7.5% of patients who were admitted to hospital during the fiscal year 2000 experienced one or more adverse events.[1] Medications and injectable solutions were the second most common causes of adverse events.[1]

Technologies that are used to automate the dispensing and administration of medications may decrease medication errors, improve quality of care, and reduce the cost that is associated with adverse events due to medication errors. These technologies include automated medication dispensing devices, bar-coding verification for medication dispensing and administration, and electronic medication administration records. Informed decision-making about the use of these technologies requires an assessment of the clinical and economic consequences of their adoption in a Canadian setting.

Objective

This report describes an assessment of the clinical and economic impact of adopting technologies that are designed to facilitate medication dispensing and administration in hospitals by addressing the following research questions:

- What is the clinical effectiveness of using technologies that are intended to reduce medication errors in hospitals in preventing medication errors, potential adverse drug events, adverse drug events, morbidity, and mortality?
- What is the cost-effectiveness of using technologies that are intended to reduce medication errors in hospitals?
- What is the budget impact of adopting these technologies in hospitals in terms of initial capital investment, training at implementation, training required for new employees, maintenance costs, and operational costs (for example, database updates, software updates, hardware, and human resources)?

Methods

A search for systematic reviews, health technology assessments, and clinical studies with comparison groups was conducted. A narrative synthesis of economic evaluations was performed. A primary economic analysis was also completed.

Results

Clinical

One systematic review[2] was identified during the literature search, but it did not meet the criteria for quality. As a result, a new systematic review was conducted.

Two studies[3,4] on pharmacy-based automatic dispensing devices showed a decrease in dispensing errors. These devices are no longer available for purchase. Five studies[5-9] were conducted on pharmacy-based automatic dispensing devices available in Europe, and the results may not be applicable to Canadian hospital pharmacies.

Carousel systems (a series of revolving shelves set on rails) reduced filling or dispensing errors, according to three studies.

Three[3,10,11] studies on profiled, ward-based automatic dispensing devices showed a decrease in dispensing or medication errors and an increase in medication errors in the cardiac intensive care unit.[3] These three studies were conducted using an older model of device. In a more recent study,[12] which did not specify the model of the device that was used, medication-related events were decreased.

Among studies on the replacement of paper medication administration records with bar-coding,[13-23] one study[13] did not detect a difference in medication errors, one[16] showed an increase in medication administration errors, two studies[14,17] showed a decrease in medication errors, and three studies[18-20] showed a decrease in medication administration errors. In one of three studies that used bar-coding for the administration of blood products, one wrong transfusion was avoided among 50 units of blood that were transfused.

In six studies that evaluated the simultaneous use of several technologies,[24-29] the treatment groups experienced reduced error rates.

Economic

Economic review

A systematic review of available economic studies on the automation of medication dispensing and administration in hospitals was conducted.

There is evidence that nursing time is saved with the use of automatic dispensing devices.[3,30,31] Less storage space may be needed with the use of pharmacy-based dispensing devices.[6,7] The financial analyses indicated that, overall, there would be savings to hospitals.[3,31-33] In studies from the United States, savings accrue to hospitals because the use of automated systems allows for more complete billings. These savings do not apply to Canada.

Economic model

An economic model was designed to explain the difference in costs when a manual drug distribution system (with medication cassettes) is compared with ward-based automated dispensing devices (with or without patient medication profiles).

When the analysis was conducted for unprofiled devices, there were savings of approximately $34,000 per patient care unit annually. Each intensive care unit had additional costs of $17,000, annually. After discounting and adjusting for inflation, there were net savings of $152,000 per patient care unit during a five-year period. Each intensive care unit costs an additional $75,000. Overall, a 400-bed hospital would achieve a five-year savings of $2.7 million with the use of unprofiled equipment. The savings would be $2.2 million if profiled units were acquired.

Sensitivity analyses showed that these results were robust for an unprofiled system. In several sensitivity analyses, a profiled automated system was more costly than a manual system.

Budget Impact

The equipment costs for each patient care unit or intensive care unit are $123,000 for an unprofiled automatic dispensing device and $138,000 for a profiled device. The planning costs are $73,800 and $82,800. The upfront costs are $196,800 and $220,800 per patient or intensive care unit for unprofiled and profiled automatic dispensing devices respectively.

For a 400-bed hospital, with approximately nineteen 20-bed patient care units and two eight-bed intensive care units, there would be upfront capital costs, as follows:

- For an unprofiled system, the cost of capital equipment would be $2.5 million and planning costs would be $1.5 million, for a total of approximately $4 million.
- For a profiled system, the cost of capital equipment would be $2.9 million and planning costs would be $1.7 million, for a total initial outlay of $4.6 million.

Limitations

The findings of the systematic review for the clinical analysis are limited because of several factors. The definitions that were used to describe the outcomes were inconsistent among studies. The errors were counted using different methods. Compelling evidence was lacking. Observational study designs were used in all of the studies. Most were uncontrolled before and after studies in which the participants were not blinded to the purpose of the study. Not all studies reported the use or results of statistical tests of significance. Factors other than automation may have led to changes in work practices. All of these factors could have affected the error rates, and the risk reduction may have been overestimated.

In the economic review, most studies had limitations. There was an absence of statistical tests of significance in the studies that were not conducted by modelling. Some of the studies on workload showed mixed results. Many costs were excluded from some of the studies. None of the studies looked at the clinical significance of medication errors or the downstream costs.

There is some outstanding uncertainty regarding budget impact as these results are sensitive to underlying assumptions regarding equipment costs. Actual budget impact may change if more precise data are obtained.

Conclusions

From a clinical perspective, based on studies of lower internal validity, the use of bar-coding for medication dispensing systems, bar-coding for medication administration systems, and the simultaneous use of technologies reduced the risk of dispensing or medication errors in hospitals. Studies of previous models of profiled, ward-based automatic dispensing devices also reported benefits. One study showed an increase in error rate in a cardiac intensive care unit. The magnitude of benefit from pharmacy-based automatic dispensing devices cannot be reliably estimated, because the studies were conducted using equipment that is no longer available for purchase or the studies used devices available in Europe. How automation affects the rate of potential adverse drug events, actual adverse drug events, morbidity, and mortality also cannot be reliably estimated, because these outcomes were not measured in most studies.

The implementation of a ward-based automatic dispensing device in a hospital can reduce costs while reducing error rates. This conclusion is only valid for medical-surgical patient care units. The implementation of ward-based automatic dispensing devices in the intensive care unit results in a net increase in costs. This is due to the large capital expenditures that are incurred for a small number of patients. There is also uncertainty about the clinical impact of this type of automation in intensive care. The results are more robust for unprofiled rather than profiled systems. The economic impact of other technologies cannot be reliably estimated, because of gaps in knowledge.

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