

ECONOMIC EVALUATION OF THE DEPLOYMENT OF ELECTRONIC DISPENSER IN INTENSIVE CARE UNIT

ABSTRACT

Introduction: Electronic dispensers of drugs and materials are automated dispensing systems that allow the control and maintenance of decentralized stocks contributing to patient safety. Objective: To describe the process of implantation of an electronic dispensary in an intensive care unit (ICU), to estimate the costs of implantation and time of return of investment, comparing pre and post implantation data. Methodology: data collection regarding cost, consumption and return of medicines and health products (PPS), as well as estimate of the cost of labor before and after the implementation of the dispensary and estimation of the time of return of investment. Results: comparing the pre and post periods, the value of drug consumption and PPS had an average reduction of 5.15% per month. Regarding the return of medicines in monetary terms, the average reduction was 91.49% per month. The return on investment occurs in 20.1 months. Conclusion: the implementation of the electronic dispensary showed a reduction of the items consumed and the return of medicines, contributing to cost reduction. Despite the initial investment cost the dispensary has a short / medium term return on investment.

Keywords: Medication systems in the hospital; costs and cost analysis; intensive care units.

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INTRODUCTION

Automated drug delivery systems, popularly known as electronic dispensers for drugs and materials, are a promise of improved patient care, reduced medication errors, decreased costs, and a closer approximation of the pharmacist to direct patient care.^{1,3} According to a technical opinion issued by the Health Technology Assessment Institute, electronic dispensaries can be defined as dispensing devices through an interface between the prescription and the equipment and can be classified as centralized (when located within the pharmacy service) or decentralized (if they are deployed in inpatient units). These systems allow the maintenance of decentralized stocks, however, controlled by the pharmacy staff.⁴

The involvement of the assistance team in the implementation of this new technology is fundamental.² Stages of the implantation include the planning of the interface of the systems, the equipment and the institution, formation of interdisciplinary group to follow the process of implantation of the equipment, trainings and continuous education.⁵

Electronic dispensers usually have high initial investment, but studies have shown that there is financial return to the institution.^{6,7} For the items to be withdrawn from the electronic dispensary, these must be linked to a prescription, which allows the reimbursement of these items by the hospital institution. The electronic dispenser ensures greater inventory control, which also reflects better financial control. In addition, there is a reduction in the number of personnel involved in the logistics of medicines, also decreasing in this way costs.¹ Other gains with the implantation of electronic dispensaries are related to the decrease in the values of inventory, greater control of the validity of the items and reduction of the time

spent by the nursing with trips to the pharmacy for the withdrawal of medicines.^{6,7}

In addition to the economic impact, the implementation of the dispensary brings benefits related to patient safety. There are reports showing that the greater the workload of the nursing team, the greater the chances of errors occurring related to care.^{8,9} A French observational study (2010) found that the rate of medication errors is lower in an Intensive Care Unit (ICU) with an electronic dispensary.²

The hospital pharmacy services have used technologies such as the dispensary to seek greater efficiency in their processes.^{1,10} Data from 2014 show that at least 53% of Canadian hospitals and 89% of North American hospitals have already incorporated electronic dispensaries into their routines.¹ However, there are few reports of the implantation of this technology in Brazil. Associated with this, the high cost and the difficulty of measuring safety outcomes, raise doubts as to the actual economy and safety gain of this technology. In this way, the objective of this work is to describe the process of implantation of an electronic dispensary in an ICU; to carry out the economic evaluation of the implantation of this equipment, comparing data of consumption and returns of medicines and health products (PPS) before and after the implantation; and estimate time of return on financial investment.

METHODOLOGY

A descriptive, observational study performed at the ICU of the hospital specialized in transplants of a large multiblock hospital in the south of Brazil, composed of seven tertiary hospitals of different specialties. The hospitals have computerized and individualized system of prescription of medicines and PPS, and traceability by bar codes.

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The ICU where the study was carried out has 11 beds and the care team consists of 17 contracted doctors, 10 nurses and 35 nursing technicians, medical and non-medical residents. The bed occupancy rate in the period from January 2016 to August 2017 was 86.84%, with an average stay of the patient in the ICU of 5.49 days. In the mentioned period, most patients received care through the Unified Health System (82.96%).

By 2015, the institution had a centralized pharmacy model, from which drugs were dispensed to the seven hospitals. The pharmacy service underwent a process of decentralization that began at the end of 2015, where each hospital started to have its own hospital pharmacy (internal pharmacy), keeping the distribution system individualized and dispensing medications and PPS. This process of decentralization was finalized in July 2016, and the hospital of transplants was the last one to implant its internal pharmacy. In August of the same year, the electronic dispensary was implanted in the ICU of this hospital.

The implementation of the electronic dispensary in the ICU occurred in August 2016. The ICU was chosen because it has few beds and adequate physical space for the installation and use of the dispensary. Before the installation of the equipment, the professionals were sensitized for their use, and after that, the staff of the manufacturer company was trained in the different shifts. The group formed to guide the implementation process involved the company team and representatives of the various sectors of the hospital, such as: quality; controlling costs and budgets; billing and covenants; information Technology; and supplies - which involves stock management and the pharmacy service.

The choice of items that make up the dispensary was performed through the analysis of the ABC curve of the items consumed by the ICU in the period of one year. Priority was given to items classified as A and B. Inclusions and exclusions were assessed according to the needs pointed out by the team, continuous observation of the consumption and organization of the physical space of the dispensary.

The information regarding the process of implantation of the dispensary was obtained through records of the Pharmacy Service and the computerized system of the institution. The items were grouped into medications and PPS. Data were collected on these items referring to consumption, return, and care provided by the internal pharmacy to the ICU.

For consumption and return data, the study period is divided into two: the first, pre-implantation of the dispensary, with the central pharmacy model (February to July 2016) and the second, after the implantation of the electronic dispensary in the ICU and with the decentralized pharmacy model (February to July 2017). It was considered as ICU consumption the difference between dispensed items and items returned; and as a return, items that were dispensed but were not used to the patient and returned to the pharmacy. In the hospital, it is possible to perform two types of return: "Return per patient", in which the unit removes the item in question from the patient's account and has a predetermined period to be made; and "return by unit", referring to items returned outside the established period and that are returned by the unit and not in a specific patient's account.

Data on visits by the internal pharmacy reflect moments of failure in the use of the electronic dispensary. These were times when the ICU team

faced problems in the use of the electronic dispensary that prevented the removal of items from the equipment. In these situations, the attendance of the items was performed by the hospital's internal pharmacy.

The calculation of the return on financial investment was made using the calculation drawn up by the hospital institution's controller. Estimates of monthly expenditures in the pre- and post-implantation periods were made with the nursing staff and pharmacy staff to attend medication and PPS to the ICU. Expenditures on drug consumption and PPS were also estimated in both periods. The average monthly difference in spending on labor and consumption of medicines and PPS between the periods corresponds to the savings generated from the implementation of the dispensary. The return on investment is calculated using the total amount spent on the acquisition of equipment divided by the estimated monthly savings. The result obtained is the number of months necessary for the monthly savings generated to be enough to pay the amount invested in the equipment.

For the quantification of the cost of the workforce of the team, it was observed the time that the employees dedicated themselves to activities related to the logistics and management of medicines and PPS: time spent to request materials for the pharmacy daily and extra requisitions carried out by the team, time that the pharmacy staff takes to meet the prescriptions, time of displacement between the ICU and the pharmacy of the nursing technicians, time spent to make returns of materials by the nursing team and the pharmacy and inventories. Dedicated employee time data for each activity were obtained by averaging 10 direct observations of each activity and counted in minutes. The periodicity of these activities and the value of the employee's salary were considered.

In order to estimate salary costs and equipment acquisition, the information available from Catho Online Ltda¹¹ and in a study carried out by de-Carvalho et al.,¹² respectively.

Data were recorded and analyzed in Excel (year 2010, version 14.0.7188.5002) and expressed in absolute and relative values.

The project was approved by the Institutional Research Ethics Committee under number CAAE 65915617.8.0000.5335.

RESULTS

In the month of implementation of the dispensary (August 2016) there were 193 different types of medicines and PPS registered in the electronic dispensary, totaling 5,663 units, equivalent to R\$ 18,994.27. One year later, in August 2017, the electronic dispensary had 277 different types of drugs and PPS registered, totaling 7,013 units, equivalent to R\$ 42,339.81. This corresponds to a 43.52% increase in registered items (increase of 23.84% in the number of units and 122.91% in the value of the stock).

Data on drug consumption and PPS in the analyzed periods are shown in table 1.

The data referring to the return of medicines and PPS, both in terms of "return per patient" and "return per unit", are described in table 2. It should be noted that prior to the implementation of the dispensary the unit did not return per patient of PPS.

Table 1: Average monthly consumption in quantity and values (R\$) of medicines and Health Products (PPS) in the pre-implantation periods (February to July 2016) and post-implantation (February to July 2017) of the electronic dispensary in the ICU of a hospital specialized in transplantation in southern Brazil.

	Pre-deployment		Post-deployment		Absolute difference		Relative difference	
	Amount (units)	Value R\$	Amount (units)	Value R\$	Amount (units)	Value R\$	Amount (%)	Value (%)
Medications	15,633	157,926.43	11,747	146,229.08	-3,886	-11,697.35	-24.86	-7.41
PPS	17,476	33,050.30	11,620	34,910.02	-5,856	+1,859.72	-35.51	+5.63
TOTAL	33,109	190,976.74	23,366	181,139.10	-9,743	-9,837.64	-29.43	-5.15

Table 2: Average monthly return for the modalities devolution per patient and devolution per unit in quantity and values (R\$) of medicines and health products (PPS) in the pre-implantation periods (February to July 2016) and post-implantation (February to July 2017) from the electronic dispensary at the ICU of a transplant hospital in southern Brazil.

	Pre-deployment		Post-deployment		Absolute difference		Relative difference	
	Amount (units)	Value R\$	Amount (units)	Value R\$	Amount (units)	Value R\$	Amount (%)	Value (%)
Return per patient (medication)	1,303	12,271.27	233	1,487.71	-1,070	-10,783.56	-82.12	-87.88
Return per unit (medication)	1,053	35,328.67	45	2,562.46	-1,008	-32,766.21	-95.73	-92.75
TOTAL (medications)	2,356	47,599.94	278	4,050.17	-2,078	-43,549.77	-88.20	-91.49
Return per patient (PPS)	0	0.00	291	1,396.52	+ 291	+ 1,396.52	--	--
Return per unit (PPS)	9	9.78	52	213.08	+ 43	+ 203.30	+ 577.78	+ 2,178
TOTAL (PPS)	9	9.78	343	1,609.60	+ 334	+ 1,599.82	+ 3,811.11	+ 16,458.08

The electronic dispensary is configured to serve most of the medicines used in the ICU, except for those rarely prescribed. However, whenever there is a failure to withdraw items, ICU staff will use the internal pharmacy. From February to July 2017, a monthly average of 9,775 items was prescribed in the ICU. Of these, 2,872 (29.38%) were attended by the internal pharmacy due to some problem with the use of the dispensary, such as lack of stock or difficulties of the team with the use of the equipment.

Table 3 shows the average monthly cost with human resources (HR) for the execution of the different activities related to the management and logistics of medicines and PPS in the pre- and post-implantation periods of the electronic dispensary.

Table 3: Estimated monthly average cost for the execution of activities related to the management and logistics of medicines and PPS in the pre-deployment periods (February to July 2016) and post-deployment (February to July 2017) of the electronic dispensary in the ICU of a hospital specialized in transplantation in southern Brazil.

Activities	Professional	Frequency	Duration (hours/month) *	Monthly amount (R\$)
Pre-dispensary				
Realization of requisitions for ICU ¹	D	Daily	77.0	440.21
Extra requisitions with offset ¹	A	Daily	16.0	160.95
Prescription service ²	B	Daily	5.0	28.56
Prescription service ³	A	Daily	5.0	45.07
Return by patient (Pharmacy)	B	Monthly	6.0	36.30
Return by patient (Nursing)	A	Monthly	6.0	57.28
Return per unit (Pharmacy)	B	Monthly	8.0	48.85
Return per unit (Nursing)	A	Monthly	8.0	77.09
Return per unit (administrative assistant)	C	Monthly	8.0	60.11
ICU Inventory Count	F	Monthly	6.0	100.38
ICU Inventory Count	B	Monthly	6.0	37.66
TOTAL				1,092.45
Post-dispensary				
Realization of requisitions ¹	D	Daily	63.0	357.55
Prescription service ²	B	Daily	9.0	57.74
Prescription service ³	A	Daily	9.0	91.12
ICU Inventory Count	E	Monthly	1.0	16.73
ICU Inventory Count	B	Monthly	1.0	6.28
Dispensary Inventory Count	E	Quarterly	1.3	22.31
Dispensary Inventory Count	B	Quarterly	1.3	8.37
Dispensing supplies	B	Daily	20.0	125.52
TOTAL				685.61

¹Consider the number of requisitions held in one month; ²Consider the biping time of items; ³Consider the time of travel of the nursing technician to the pharmacy. (A) Nursing technician – 180 hours, R\$ 9.90/hour. (B) Supplies assistant – 220 hours, R\$ 6.27/hour. (C) Administrative Assistant – 220 hours, R\$ 7.72/hour. (D) Administrative Assistant of the ICU – 220 hours, R\$ 5.72/hour. (E) Pharmacist – 180 hours, R\$ 16.73/hour. Salary values obtained at <https://www.catho.com.br/profissoes/>, accessed on 11/23/2017. *Data obtained through the average of 10 direct observations of each activity.

Table 4 presents the estimated savings data from the reduction of costs with items consumed and with HR. With this data, it is possible to estimate the time of return of the financial investment.

Table 4: Calculation of financial return of the implantation of an electronic dispensary in the ICU of a specialized hospital in transplants of Porto Alegre/RS.

Cost, Economy and time of return of the investment with the dispensary	Price R\$
Cost (A)	
Acquisition of dispensary ¹	206,065.88
Economy (B)	
Estimate of monthly savings with HR	406.84
Estimate of monthly savings with stock consumption	9,837.64
Average monthly economy estimates	10,244.48
Return on investment time (A/B)	
Time in months	20.1

¹Value of acquisition of the electronic dispensary obtained in de-Carvalho et al., 2017

HR: refers to human resources.

DISCUSSION

The implantation of electronic dispensaries tends to demonstrate a decrease in the consumption of medicines and PPS. As shown in table 1, we observed a reduction in consumption of 24.86% in the quantity of medicines and 35.51% in the quantity of PPS, which led to an overall reduction in consumption values of 5.15%.

Roman et al. also reported on the deployment of electronic dispensaries in an Australian hospital that had decentralized stocks in the units and observed a reduction in drug consumption.¹³ Chapuis et al. demonstrated a reduction of approximately 50% in the quantity of drugs in stock in an ICU and 47.22% in the stock value after implantation of an electronic dispensary.⁷

At the ICU investigated, medication returns decreased in quantity (88.20%), whereas for PPS, there was an increase of 3,811.11% (table 2), which may be related to the stock without the necessary control before deployment. With the electronic dispensary, there is a return stimulus per patient (especially related to PPS) and a decrease of returns per unit (not recommended).

Table 2 shows, positively, that unit returns of drugs decreased by 95.73% after the implementation of the electronic dispensary. Returning by unit, although allowed, is not recommended by the institution, as it generates less inventory control and indicates a failure in the item return process. Thus, the decrease in medication returns and the increase in the return of PPS in the most indicated manner (return per patient) leads us to infer that the electronic dispensary has contributed to the inventory management of the unit.

There is an interface between the electronic dispensary and the computerized hospital system, and thus, the suspensions of a prescription medication or discharge of patients are integrated in such a way that they are not released by the dispensary. In addition, the dispensing of drugs prescribed as "if necessary" occurs only if there is a real need for use by the patient, including increasing safety.³ These data show the contribution of the electronic dispensary to inventory control, both regarding consumption and return.

A failure in the implantation of the equipment can be indicated by the high number of visits by the internal pharmacy of items belonging to the electronic dispensary - about 30% of the items prescribed in the ICU were withdrawn at the pharmacy and not at the dispensary. Future evaluation involving the electronic dispensing replenishment flow may be necessary to identify process failure points. The creation of an own work team for the electronic dispensary can bring benefits to this process.

Table 3 shows a decrease in the time devoted to the implementation of requisitions for the ICU and a decrease in the activities of nursing technicians with logistics and inventory control. The time when nursing is involved with medication issues interferes with the time available for direct patient care. Decreased time spent by nursing with medication management can lead to decrease of medication errors and forgetfulness of doses.^{13,14} One of the explanations may be the fact that computerization makes the work more agile in the inventory query in units accustomed to working with decentralized inventories.¹³

The return on investment estimated in table 4 shows that the savings generated by the decrease in consumption with the electronic dispensary and the reduction of costs with HR are able to pay off the investment in approximately 20 months - a medium period of time, a result consistent with other studies.^{1,7,12}

Electronic dispensaries have been studied as alternatives to the drug distribution processes in hospitals. It is a health technology not well-known in Brazil, with the potential to reduce medication errors.^{10,13} Its benefits have been measured and involve increased safety,^{13,14} the dispensing efficiency of the medicinal products,¹³ in addition to more accurate inventories and increased traceability in drug use and access.^{7,13} With this, it is observed reduction of inventories, diversion of medicines and increase of the financial return.^{7,13} In short, electronic dispensaries are deployed in hospital units with the expectation of increasing human resource efficiency and increasing the quality of drug distribution systems.¹⁵

To increase safety, some electronic dispensers are susceptible to settings such as use of alerts when detected incomplete dose withdrawal or exchange of medication and disposition of items within the dispensary, leaving away those with a similar name or packaging.^{3,14} In addition, the interface between the systems of the electronic dispensary and the hospital contributes to the increase of patient safety.⁷ The safety barriers created in the electronic dispensary of this study deal with the disposition of items in the equipment, mandatory counts when withdrawing certain items - especially psychotropic medications - and drawers that allow the withdrawal of only one item at a time, used for drugs with greater adverse event potential.

In this study, it was not possible to account for medication errors in the pre- and post-implantation period of the electronic dispensary, but a decrease in the number of occurrences of errors.¹ An Australian study of 2016 showed that an emergency room with electronic dispensary had 64.7% fewer medication errors compared to one without the equipment and with decentralized stock.¹⁴

This study presents some limitations, the first one refers to the use of secondary and retrospective data, which may contribute to the lack of accuracy of the data. Only the items used by the patients were considered as consumption. However, there are items dispensed to unit, which were not considered. As the amount of items dispensed in this way is small it is believed that it would not bring significant difference in the obtained result. The number of observations made to measure the time expended in the activities performed by the employees to compute the expenditure with human resources was small, which can lead to times different from those used. It was not included in the costs the expense with the maintenance of the equipment, as well as the hours of training. In any case, the data presented contribute to better understand the process of implantation of an electronic dispensary in a Brazilian hospital and provide subsidies for adoption of the technology in other ICUs of the hospital complex.

Final Considerations

This paper presents the results of the evaluation of the pilot project of implantation of electronic dispensaries in intensive care units. Positive financial returns were observed, although the cost of the equipment is still considered high. The monitoring by the pharmacy team is important so that the necessary support is given to the users of the equipment, therefore, it is worth remembering that, although it is a decentralized stock, it is still the responsibility of the pharmacists. Monitoring is critical to the success of this technology. In future work, we have as perspective the evaluation of the impact of the electronic dispensary in the reduction of medication errors, when implanted in other ICUs.

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Contributors

SBP designed study, collected and interpreted study data and performed article writing. LHL and FV collected and interpreted study data. CRB and ALC designed study and interpreted study data. All authors are responsible for the article information and have approved the final version for publication.

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Conflicts of interest

The authors declare no conflicts of interest

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