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Effectiveness of the automated drug dispensing system: systematic review and meta-analysis

Efetividade do sistema de dispensação eletrônica de medicamentos: revisão sistemática e metanálise

Eficacia del sistema de dispensación electrónica de medicamentos: revisión sistemática y metaanálisis

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ABSTRACT

Objectives: to compare the effectiveness of the decentralized automated drug dispensing system with pockets. **Methods**: an effectiveness study based on a systematic review guided by the question: for patients admitted to hospital units, is the use of automated drug dispensing effective for reducing medication errors when compared to manual unit dose dispensing? The evidence was evaluated by the Grading of Recommendations Assessment, Development and Evaluation and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses instrument, used in the report. **Results**: the sample was composed of 15 studies and none of them directly compared both technologies; however, the meta-analysis showed that there is no difference in effectiveness between them [OR 1.03 95%CI (0,12 – 8,99)]. **Conclusion**s: the conclusion is that the recommendation in favor of the automated dispensing system is weak.
Descriptors: Medication Systems, Hospital; Patient Safety; Medication Errors; Technology Assessment, Biomedical; Comparative Effectiveness Research.

RESUMO

Objetivos: comparar a efetividade do sistema automatizado de distribuição descentralizada de medicamentos por armário. **Métodos**: trata-se de estudo de efetividade embasado por revisão sistemática, norteada pela questão: Para pacientes internados em unidades hospitalares, o uso de dispensário eletrônico é efetivo para a redução de erros de medicação comparado à dispensação manual por dose unitária? O conjunto da evidência foi avaliado pelo *Grading of Recommendations Assessment, Development and Evaluation*, sendo o instrumento *Preferred Reporting Items for Systematic Reviews and Meta-Analyses* usado no relatório. **Resultados**: a amostra foi composta por 15 estudos e nenhum deles comparou diretamente as tecnologias, contudo, a metanálise revelou que não existe diferença de efetividade entre elas [OR 1.03 IC 95% (0,12 – 8,99)]. **Conclus***ões*: conclui-se que a recomendação é fraca a favor do dispensário eletrônico.
Descritores: Sistemas de Medicação no Hospital; Segurança do Paciente; Erros de Medicação; Avaliação da Tecnologia Biomédica; Pesquisa Comparativa da Efetividade.

RESUMEN

Objetivos: comparar la eficacia del sistema automatizado de distribución descentralizada de medicamentos por armario. **Métodos**: se trata de un estudio de efectividad basado en una revisión sistemática guiada por el tema: Para los pacientes ingresados en los hospitales, ¿el uso del dispensario electrónico es eficaz para reducir errores de medicación en comparación con la dispensación manual por dosis unitaria? El conjunto de la evidencia se evaluó según los sistemas GRADE (evaluación de la calidad de la evidencia y graduación de la fuerza de las recomendaciones) y PRISMA (elementos de informes preferidos para los protocolos de revisión sistemática y metaanálisis) usado en el informe. **Resultados**: la muestra estaba compuesta de 15 estudios y ninguno comparó directamente las tecnologías; sin embargo, el metaanálisis mostró que no existe diferencia de la eficacia entre ellas [OR 1.03 IC 95% (0,12 – 8,99)]. **Conclusiones**: se ultima que la recomendación es débil a favor del dispensario electrónico.
Descriptores: Sistemas de Medicación en Hospital; Seguridad del Paciente; Errores de Medicación; Evaluación de la Tecnología Biomédica; Investigación sobre la Eficacia Comparativa.

INTRODUCTION

Drug administration errors are significantly reduced with the adoption of unit dose delivery systems and automated systems. In this context, an automated system of decentralized drug distribution through organized compartments or pockets stands out. This system is known as "automated dispensing cabinets (ADC)" or "automated dispensing system (ADS)"[1]. This technology has been associated with a 56% reduction in medication administration errors and is characterized as a system with security levels that limit the access of professionals[2-3].

The use of an automated decentralized drug dispensing system with cabinets has a significant role in nursing care practice, as it influences work routine and patient safety. However, data on the effectiveness of the ADS in relation to the reduction of drug errors are scarce in the Brazilian literature. In addition, the number of manufacturers is small, increasing the need to fully understand the potential of this technology[1-3].

OBJECTIVES

To compare the effectiveness of the decentralized automated drug dispensing system with pockets in relation to the reduction of medication errors in hospitalized adult patients.

METHODS

This is a study of direct comparative effectiveness, using the head-to-head method. Systematic review was used to synthesize the available evidence[4]. Comparative effectiveness research (CER) is the synthesis of evidence that compares the benefits and harms of alternative methods to prevent, diagnose, treat and monitor a clinical condition, or to improve the delivery of care, with the purpose of assisting consumers, clinicians, purchasers and policy makers to make informed decisions that will improve health care at both the individual and population levels[5].

The review followed the steps recommended by the Methodological Guidelines for Systematic Reviews of the REBRATS (Brazilian Health Technology Network)[6]. The research question was based on the acronym PICO (patient, intervention, comparison, outcomes) and was defined as follows: For patients admitted to hospital units, is the use of automated drug dispensing effective for reducing medication errors when compared to manual unit dose dispensing?

Information retrieval occurred from August to November 2016, on the Virtual Health Library (VHL) Regional Portal, on Medical Literature Analysis and Retrieval System Online (MEDLINE) via PubMed, in the multidisciplinary databases SCOPUS (Elsevier), Web of Science (WOS) (Thompson) and Cumulative Index to Nursing and Allied Health Literature (CINAHL) (EBSCO), via *portal de Periódicos da Capes*, in the databases Cochrane Library of John Wiley & Son and EMBASE of Elsevier, in Portal PROQUALIS (Fiocruz) and in Capes' thesis and dissertations database. Inclusion criteria were studies in Portuguese, Spanish and English, involving adult patients over 18 years old, admitted to a hospital unit, with a length of stay of 12 hours or more in the emergency, intensive care, medical and surgical sectors, using intravenous, oral, sublingual, intramuscular, subcutaneous and inhalation drugs. The search strategies used to retrieve information are described in Chart 1.

Studies excluded were: those developed outside the hospital environment; outpatient clinics, emergency units, health centers, obstetric clinics, pediatric and/or neonatal clinics.

The studies were independently evaluated by a pair of reviewers, considering the steps proposed by the Prisma Flow[7] (Figure 1). Disagreements about the inclusion of studies in the review were decided by consensus among the reviewers. Based on the full reading of the eligible articles, the following information was extracted: authors, study design and population, intervention, outcome, results and limitations. The information was organized in a spreadsheet to facilitate data synthesis.

Chart 1 – Search strategy per database, Rio de Janeiro, Rio de Janeiro, Brazil, 2016

Databases	Search strategies
Medical Literature Analysis and Retrieval System Online via PubMed	(((“Drug Dispensed”[Title/Abstract] OR “Drug dispensers”[Title/Abstract] OR “Drug dispenser”[Title/Abstract] OR “Drug dispenses”[Title/Abstract] OR “Drug dispensing”[Title/Abstract]) OR (“medication systems, hospital”[MeSH Terms] OR (“Hospital Medication System”[Title/Abstract] OR “Hospital Medication Systems”[Title/Abstract]))) AND ((((((“Automated dispensing cabinet”[Title/Abstract] OR “Automated dispensing machines”[Title/Abstract] OR “Automated dispensing devices”[Title/Abstract] OR “Automated medication dispensing cabinet”[Title/Abstract] OR “Robotic Dispensing System”[Title/Abstract] OR “Automated drug distribution cabinet system”[Title/Abstract] OR “Distribution cabinet system”[Title/Abstract] OR Medstation[Title/Abstract] OR Robot[Title/Abstract] OR Unit-based[Title/Abstract] OR Cabinets[Title/Abstract]) OR ((“point of care systems”[MeSH Terms] OR “point of care systems”[Title/Abstract]) OR (“Point of Care Systems”[Title/Abstract] OR “Point-of-Care System”[Title/Abstract] OR “Point-of-Care”[Title/Abstract] OR “Point of Care”[Title/Abstract] OR “Bedside Computing”[Title/Abstract] OR “Point of Care Technology”[Title/Abstract] OR “Bedside Technology”[Title/Abstract] OR “Bedside Technologies”[Title/Abstract]))) OR (“drug storage”[MeSH Terms] OR ((“storage drug”[Title/Abstract] OR “storage drugs”[All Fields]) AND Title/Abstract[All Fields]))) OR ((“automatic data processing”[MeSH Terms] OR “automatic data processing”[Title/Abstract]) OR (“Electronic Data Processing”[Title/Abstract] OR “Computer Data Processing”[Title/Abstract] OR “Data Processing Computer”[Title/Abstract] OR “Data Processing Automatic”[Title/Abstract] OR “Optical Readers”[Title/Abstract] OR “Optical Reader”[Title/Abstract] OR “Reader Optical”[Title/Abstract] OR “Information Processing”[Title/Abstract] OR “Processing Information”[Title/Abstract] OR “information Processing Automatic”[Title/Abstract] OR “Automatic Information Processing”[Title/Abstract] OR “Bar Codes”[Title/Abstract] OR “Bar Code”[Title/Abstract] OR “Code Bar”[Title/Abstract]))) OR (((((((“medication therapy management”[MeSH Terms] OR “medication therapy management”[Title/Abstract]) OR “medication therapy management”[Title/Abstract]) OR “management medications”[Title/Abstract]) OR “therapy management practice”[Title/Abstract]) OR “drug therapy management”[Title/Abstract]) OR “management drugs”[Title/Abstract]) OR “therapy management group”[Title/Abstract]))) AND (((((“inpatients”[MeSH Terms] OR Inpatients[Title/Abstract]) OR Inpatient[Title/Abstract]) OR (((((((((“adult”[MeSH Terms] OR Adult[Title/Abstract]) OR Young Adult[Title]) OR “young adult”[MeSH Terms]) OR Aged[Title]) OR “aged”[MeSH Terms]) OR Aged[Title/Abstract]) OR (Midlle[All Fields] AND “aged”[MeSH Terms])) OR (Midlle[All Fields] AND Aged[Title/Abstract])) OR “adults”[Title/Abstract])) OR ((((“drug utilization”[MeSH Terms] OR “utilization drug”[Title/Abstract]) OR “drug utilization”[Title/Abstract]) OR “drug utilizations”[Title/Abstract])) OR ((((“administration, intravenous”[MeSH Terms] OR “administration intravenous”[Title/Abstract]) OR (“intravenous administration”[Title/Abstract] OR “intravenous administration 10”[Title/Abstract])) OR “intravenous administrations”[All Fields]) OR “administration intravenous”[All Fields])) AND (“humans”[MeSH Terms])

To be continued

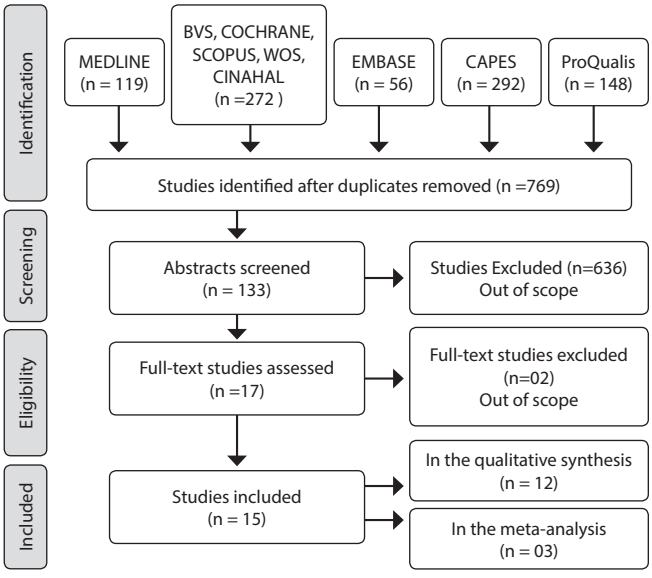
Chart 1

Databases	Search strategies
SCOPUS	((TITLE-ABS-KEY (inpatients OR inpatients OR inpatient OR adult OR adults OR "Young Adult" OR aged OR "Midlle Aged" OR "drug utilization" OR "utilization drug" OR "drug utilization" OR "drug utilizations" OR "administration intravenous" OR "administration intravenous") OR TITLE-ABS-KEY ("intravenous administration" OR "intravenous administrations" OR "administration intravenous"))) AND (((TITLE-ABS-KEY ("Automated dispensing cabinet" OR "Automated dispensing machines" OR "Unit dose dispensing robot" OR "Automated dispensing devices" OR "Automated medication dispensing cabinet" OR "Unit-based cabinets" OR "Automated distribution cabines") OR TITLE-ABS-KEY ("Robotic Dispensing System" OR "Automated drug distribution cabinet system" OR "Distribution cabinet system" OR "Dispensing administration" OR medstation OR omnicel OR robot OR unit-based OR cabinets OR "point of care systems" OR "point of care systems") OR TITLE-ABS-KEY ("Technology Bedside" OR "Technologies Bedside" OR "drug storage" OR "Drug Storages" OR "storage drug" OR "storage drugs" OR "automatic data processing" OR "automatic data processing" OR "Electronic Data Processing"))) OR ((TITLE-ABS-KEY ("Data Processing Electronic" OR "Processing Electronic Data" OR "Computer Data Processing" OR "Data Processing Computer" OR "Processing Computer Data" OR "Data Processing Automatic" OR "Processing Automatic Data") OR TITLE-ABS-KEY ("Optical Readers" OR "Optical Reader" OR "Reader Optical" OR "Readers Optical" OR "Information Processing" OR "Processing Information" OR "information Processing Automatic" OR "Automatic Information Processing") OR TITLE-ABS-KEY ("Processing Automatic Information" OR "Bar Codes" OR "Bar Code" OR "Code Bar" OR "Codes Bar" OR "medication therapy management" OR "medication therapy management" OR "medication therapy management" OR "management medications") OR TITLE-ABS-KEY ("therapy management practice" OR "drug therapy management" OR "management drugs" OR "therapy management group")))) AND ((TITLE-ABS-KEY ("Drug Dispensatories" OR "Drug Dispensed" OR "Drug dispensers" OR "Drug dispenser" OR "Drug dispensing" OR "medication systems hospital" OR "Medication Systems Hospital" OR "Drug Distribution Systems Hospital") OR TITLE-ABS-KEY ("Hospital Medication System" OR "System Hospital Medication" OR "Systems Hospital Medication" OR "Systems Medication Hospital" OR "Hospital System Medication") OR TITLE-ABS-KEY ("Hospital Systems Medication" OR "Medication Hospital System" OR "Medication Hospital Systems" OR "System Medication Hospital" OR "Hospital Unit Dose Drug Distribution System") OR TITLE-ABS-KEY ("Hospital Unit Dose Drug Distribution Systems" OR "Medication System Hospital" OR "System Hospital Medication" OR "Hospital Medication System") OR TITLE-ABS-KEY ("Hospital Medications System" OR "Medication System Hospital" OR "Medications System Hospital" OR "System Hospital Medications" OR "Drug Distribution System Hospital" OR "Hospital Medication Systems")
Web of SCIENCE	((**Tópico:** ((((((((((((((((((inpatients OR Inpatients) OR Inpatient) OR Adult) OR Adults) OR "Young Adult") OR Aged) OR "Midlle Aged") OR "drug utilization") OR "utilization drug") OR "drug utilization") OR "drug utilizations") OR "administration intravenous") OR "administration intravenous") OR "intravenous administration") OR "intravenous administration") OR "intravenous administrations") OR "administration intravenous") *AND* **Tópico:** ((("Automated dispensing cabinet" OR "Automated dispensing machines") OR "Unit dose dispensing robot") OR "Automated dispensing devices") OR "Automated medication dispensing cabinet") OR "Unit-based cabinets") OR "Automated distribution cabines") OR "Robotic Dispensing System") OR "Automated drug distribution cabinet system") OR "Distribution cabinet system") OR "Dispensing administration") OR meditation) OR omnicup) OR Robot) OR Unit-based) OR cabinet) OR "point of care systems") OR "point of care systems") OR "Point of Care Systems") OR "Point-of-Care System") OR "Systems Point-of-Care") OR "Point-of-Care") OR "Point of Care") OR "Bedside Computing") OR "Computing Bedside") OR "Point of Care Technology") OR "Bedside Technology") OR "Bedside Technologies") OR "Technology Bedside") OR "Technologies Bedside") OR "drug storage") OR "Drug Storages") OR "storage drug") OR "storage drugs") OR "automatic data processing") OR "automatic data processing") OR "Electronic Data Processing") OR "Data Processing Electronic") OR "Processing Electronic Data") OR "Computer Data Processing") OR "Data Processing Computer") OR "Processing Computer Data") OR "Data Processing Automatic") OR "Processing Automatic Data") OR "Optical Readers") OR "Optical Reader") OR "Reader Optical") OR "Readers Optical") OR "Information Processing") OR "Processing Information") OR "information Processing Automatic") OR "Automatic Information Processing") OR "Processing Automatic Information") OR "Bar Codes") OR "Bar Code") OR "Code Bar") OR "Codes Bar") OR "medication therapy management") OR "medication therapy management") OR "medication therapy management") OR "management medications") OR "therapy management practice") OR "drug therapy management") OR "management drugs") OR "therapy management group")) *AND* **Tópico:** ((((((((((((((((((((((((((((("Drug Dispensatories" OR "Drug Dispensed") OR "Drug dispensers") OR "Drug dispenser") OR "Drug dispenses") OR "Drug dispensing") OR "medication systems hospital") OR "Medication Systems Hospital") OR "Drug Distribution Systems Hospital") OR "Hospital Drug Distribution Systems") OR "Hospital Medication System") OR "System Hospital Medication") OR "Systems Hospital Medication") OR "Systems Medication Hospital") OR "Hospital System Medication") OR "Hospital Systems Medication") OR "Medication Hospital System") OR "Medication Hospital Systems") OR "System Medication Hospital") OR "Hospital Unit Dose") OR "Drug Distribution System") OR "Hospital Unit Dose") OR "Drug Distribution Systems") OR "Medication System Hospital") OR "System Hospital Medication") OR "Hospital Medication System") OR "Hospital Medications System") OR "Medication System Hospital") OR "Medications System Hospital") OR "System Hospital Medications") OR "Drug Distribution System Hospital") OR "Hospital Medication Systems"))
Cumulative Index to Nursing and Allied Health Literature	(inpatients OR Inpatients OR Inpatient OR Adult OR Adults OR "Young Adult" OR Aged OR "Midlle Aged" OR "drug utilization" OR "utilization drug" OR "drug utilization" OR "drug utilizations" OR "administration intravenous" OR "administration intravenous" OR "intravenous administration" OR "intravenous administration" OR "intravenous administrations" OR "administration intravenous") AND ("Automated dispensing cabinet" OR "Automated dispensing machines" OR "Unit dose dispensing robot" OR "Automated dispensing devices" OR "Automated medication dispensing cabinet" OR "Unit-based cabinets" OR "Automated distribution cabines" OR "Robotic Dispensing System" OR "Automated drug distribution cabinet system" OR "Distribution cabinet system" OR "Dispensing administration" OR Medstation OR Omnicel OR Robot OR Unit-based OR Cabinets OR "point of care systems" OR "point of care systems" OR "Point of Care Systems" OR "Point-of-Care System" OR "Systems Point-of-Care" OR "Point-of-Care" OR "Point of Care" OR "Bedside Computing" OR "Computing Bedside" OR "Point of Care Technology" OR "Bedside Technology" OR "Bedside Technologies" OR "Technology Bedside" OR "Technologies Bedside" OR "drug storage" OR "Drug Storages" OR "storage drug" OR "storage drugs" OR "automatic data processing" OR "automatic data processing" OR "Electronic Data Processing" OR "Data Processing Electronic" OR "Processing Electronic Data" OR "Computer Data Processing" OR "Data Processing Computer" OR "Processing Computer Data" OR "Data Processing Automatic" OR "Processing Automatic Data" OR "Optical Readers" OR "Optical Reader" OR "Reader Optical" OR "Readers Optical" OR "Information Processing" OR "Processing Information" OR "information Processing Automatic" OR "Automatic Information Processing" OR "Processing Automatic Information" OR "Bar Codes" OR "Bar Code" OR "Code Bar" OR "Codes Bar" OR "medication therapy management" OR "medication therapy management" OR "medication therapy management" OR "management medications" OR "therapy management practice" OR "drug therapy management" OR "management drugs" OR "therapy management group") AND (Distribution OR "Medication Systems" OR "Drug dispensing" OR "Distribution Systems")

To be continued

Chart 1 (concluded)

Databases	Search strategies
Virtual Health Library Regional Portal	tw:((dispensario OR distribuição OR dispensação OR armazenamento OR armazenagem OR estoque) AND (medicamento* OR droga* OR remedio*) AND (eletronico OR robotico OR robo OR automati*)) AND (instance:"regional") AND (db:("LILACS" OR "IBECS" OR "BBO" OR "DECS" OR "colecionaSUS") AND la:("es" OR "pt" OR "en"))
	#1 "inpatients" or "Inpatients" or "Inpatient" or "Adult" or "Adults" or "Young Adult" or Aged or "Midlle Aged" or "drug utilization" or "utilization drug" or "drug utilization" or "drug utilizations" or "administration intravenous" or "administration intravenous" or "intravenous administration" or "intravenous administration" or "intravenous administrations" or "administration intravenous":ti,ab,kw (Word variations have been searched) #2 "Automated dispensing cabinet" or "Automated dispensing machines" or "Unit dose dispensing robot" or "Automated dispensing devices" or "Automated medication dispensing cabinet" or "Unit-based cabinets" or "Automated distribution cabines" or "Robotic Dispensing System" or "Automated drug distribution cabinet system" or "Distribution cabinet system" or "Dispensing administration" or Medstation or Omnicel or Robot or Unit-based or Cabinets or "point of care systems" or "point of care systems" or "Point of Care Systems" or "Point-of-Care System" or "Systems Point-of-Care" or "Point-of-Care" or "Point of Care" or "Bedside Computing" or "Computing Bedside" or "Point of Care Technology" or "Bedside Technology" or "Bedside Technologies" or "Technology Bedside" or "Technologies Bedside" or "drug storage" or "Drug Storages" or "storage drug" or "storage drugs" or "automatic data processing" or "automatic data processing" or "Electronic Data Processing" or "Data Processing Electronic" or "Processing Electronic Data" or "Computer Data Processing" or "Data Processing Computer" or "Processing Computer Data" or "Data Processing Automatic" or "Processing Automatic Data" or "Optical Readers" or "Optical Reader" or "Reader Optical" or "Readers Optical" or "Information Processing" or "Processing Information" or "information Processing Automatic" or "Automatic Information Processing" or "Processing Automatic Information" or "Bar Codes" or "Bar Code" or "Code Bar" or "Codes Bar" or "medication therapy management" or "medication therapy management" or "medication therapy management" or "management medications" or "therapy management practice" or "drug therapy management" or "management drugs" or "therapy management group":ti,ab,kw (Word variations have been searched) #3 "Drug Dispensatories" or "Drug Dispensed" or "Drug dispensers" or "Drug dispenser" or "Drug dispenses" or "Drug dispensing" or "medication systems hospital" or "Medication Systems Hospital" or "Drug Distribution Systems Hospital" or "Hospital Drug Distribution Systems" or "Hospital Medication System" or "System Hospital Medication" or "Systems Hospital Medication" or "Systems Medication Hospital" or "Hospital System Medication" or "Hospital Systems Medication" or "Medication Hospital System" or "Medication Hospital Systems" or "System Medication Hospital" or "Hospital Unit Dose Drug Distribution System" or "Hospital Unit Dose Drug Distribution Systems" or "Medication System Hospital" or "System Hospital Medication" or "Hospital Medication System" or "Hospital Medications System" or "Medication System Hospital" or "Medications System Hospital" or "System Hospital Medications" or "Drug Distribution System Hospital" or "Hospital Medication Systems":ti,ab,kw (Word variations have been searched) #4 #1 and #2 and #3
EMBASE	(inpatient*:ab,ti OR 'hospital patient'/de OR 'hospital patient'/exp OR 'hospital patient':ti,ab AND ('drug utilization*':ab,ti OR 'drug use'/exp OR 'drug use':ti,ab OR 'intravenous drug administration'/exp OR 'intravenous drug administration':ti,ab)) AND ('medication therapy management'/exp OR 'medication therapy management':ti,ab OR 'drug therapy management':ab,ti OR 'hospital medication systems':ab,ti OR 'hospital organization'/exp OR 'hospital organization':ti,ab OR (storage:ab,ti AND drug*:ab,ti) OR 'drug storage'/exp OR 'drug storage':ti,ab) AND ('automatic data processing':ti OR 'information processing'/exp OR 'information processing':ti OR 'point-of-care systems':ti OR 'bedside computing':ti OR 'distribution cabinet system':ti OR 'automated dispensing cabinet':ti OR 'chest':ti OR cabinet*:ti OR 'medicine chest'/exp OR 'medicine chest':ti)
COCHRANE LIBRARY	Utilization, Drug OR Drug Utilizations AND Drug Storages OR Storage, Drug AND Safety, Equipment OR Medical Device Safety OR Device Safety AND Therapy management, drug OR Management, Medication Therapy AND Medication systems, hospital OR System, medication hospital OR Hospital unit dose drug distribution system OR Drug distribution systems, hospital AND error OR Error, medication OR Drug Use Error OR Use Errors, Drug OR Medication errors AND Healthcare Close Call OR Close Calls, Healthcare AND Safety, Patient OR Patient Safeties



Note: MEDLINE - Medical Literature Analysis and Retrieval System Online via PubMed; CINAHL - Cumulative Index to Nursing and Allied Health Literature; VHL - Virtual Health Library Regional Portal; WOS - Web of Science.

Figure 1 – Flowchart of study selection (Prisma Flow) adapted from Moher et al.[7]

A total of 769 documents were extracted. After refinement and elimination of duplicates, 15 were selected, of which 03 were included in the meta-analysis and 12 in the qualitative synthesis. The quality of the studies was assessed by the Evidence Scale of the Oxford Centre for Evidence-Based Medicine[8]. The quality of the evidence and the strength of recommendation was measured by the Grading of Recommendations Assessment, Development and Evaluation (GRADE)[9]. The measures used in the meta-analysis were (odds ratio) and RR (risk ratio).

The systematic review protocol was recorded on the International Prospective Register of Systematic Reviews (PROSPERO - CRD42017075850). The checklist used to write the article was the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA Statement).

The meta-analysis, performed by a random effect model, and the critical evaluation of the evidence were performed using the Cochrane Collaboration Review Manager 5.3 software. The odds ratio (OR) was the measure of effect size considered in the meta-analysis.

RESULTS

Of the 15 articles included in the review (Chart 2), 13 addressed the use of the ADS, 01 analyzed the use of the ADS and unit dose dispensing and 01 only addressed the implementation of unit dose dispensing.

The studies were published between 2003 and 2015, with the highest concentration between 2012 and 2015 (n=10)[10-19]. Most studies had a low level of evidence (66,67%).

The results of the meta-analysis are presented in the Forest Plot (Figure 2). It was observed that there was no statistically significant difference in effectiveness between the technologies evaluated. The use of the automated drug dispensing system was associated with an OR (Odds Ratio) of 1.03 95% CI (0.12 - 8.99) of medication errors.

The inaccuracy observed in the meta-analysis may be considered significant. With 95% confidence level, it is possible to predict that the chance of error using the electronic dispensary could range from 0.12 to 8.99. Thus, in an approximation with the relative risk (RR), it is possible to infer that the ADS can, in the best scenario, avoid errors, reducing the relative risk of occurrence of the event by 88% (OR 0.12 and RRR 0 88), although in the worst case scenario it may increase it by more than 700% (OR 8.99).

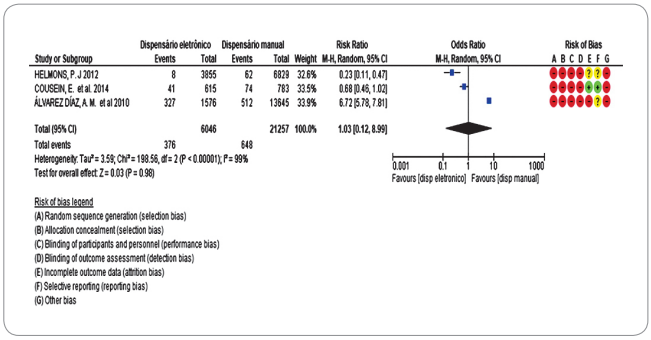


Figure 2 - Forest Plot of the meta-analysis for the outcome medication error, elaborated using RevMan 5.3 from Cochrane Collaboration

Chart 2 – Synthesis of the Studies included in the Systematic Review, Rio de Janeiro, Rio de Janeiro, Brazil, 2017

Studies	Type of study/ population/ setting	Intervention	Outcomes	Results	Limitations	Oxford
RODRIGUEZ-GONZALEZ CG et al.[10] Spain	Root Cause Analysis (FMEA) and Expert Panel. Inpatient units in a general university hospital with 1381 beds.	Drug administration in a unit that uses the Computerized Physician Order Entry connected to the automated dispensing system (ADS).	Errors and adverse events in drug administration based on a critical index (RPN >100).	Administration of medication to the patient is the phase with the highest risk (Total RPN = 2065). The recovery of medication in the ADS is in 5th place in the criticality ranking (Total RPN = 535). Most common types of errors: incorrect dose (RPN = 320); incorrect medication (RPN = 288).	Inevitable subjectivity in the selection of failure modes and calculation of the critical index. Low possibility of extrapolation of the results.	5D
CHAPUIS C et al.[11] France	Cash flow analysis – before and after. Direct observation of 20 nurses and 20 pharmacy technicians for 10 days before and after implementation. 03 surgical ICUs and a total of 2,082 admissions.	Automated drug dispensing system (Omni RX®).	Global cash flow - value of generated cash to pay back the invested capital and net present value (NPV) of the ADS. *With an annual rate of return of 4% and a residual cost at year 5 of 10% of the initial price.	Reduction of drug storage cost = 44.298 Euros. Reduction of cost of expired drugs = 14.772 Euros. Global cash flow global (at year 5) was 148.229 Euros and the net present value of the project was positive by 510.404 Euros. Average of 14.7 hours saved per day for nurses and average of 3.5 additional hours per day for pharmacy technicians.	Did not calculate fees or costs due to medication errors (Outcome of interest).	4C
COUSEIN E et al.[12] France	Descriptive, before and after. Direct observation of medication administration to 314 patients admitted to a 40-bed geriatric unit in a 1800-bed General Hospital.	Impact of change of the drug distribution system from a ward stock system to a unit dose dispensing system, integrating an ADS	Overall rate of medication administration errors.	Rate of medication administration errors before intervention = 10.6%; CI 95% 8.1-13.9%. Rate of medication administration errors after intervention = 5.0%, CI 95% 3.5-6.9% (P <0.001), Absolute risk reduction 5.7%, relative risk reduction (RRR) = 53%. Wrong dose error was reduced by 79.1% (2.4% versus 0.5%, P = 0.005) and wrong drug errors were reduced by 93.7% (1.9% versus 0.01%, P = 0.009). OR: 0.68 CI 95% (0.46-1.02)	Did not compare intervention and control.	2B

To be continued

Chart 2

Studies	Type of study/ population/ setting	Intervention	Outcomes	Results	Limitations	Oxford
LO A et al.[13] United State of American	Descriptive, before and after. Review of medical records: pre-implementation (n = 65) and post-implementation (n = 56) in a 377-bed emergency service in California.	Addition of intravenous antibiotics to ADS in patient care units.	Reduction of the time of initiation of antibiotics with the use of the ADS in the emergency department.	Reduction in order-to-administration time (from 4.5 ± 4.1 to 2.9 ± 2.5 hours, p = 0.009) for piperacillin-tazobactam first doses. There was a significant 1.7-hour reduction in the mean.	Did not use sample calculation. It cites a statistical power of 57.2%. There was discrepancy between the pre and post intervention measurement times.	2B
OTERO LÓPEZ MJ et al.[14] Spain	Survey Conducted in 36 general hospitals. Scale assessment (Likert), in which the maximum possible score was 465 (=all practices were implemented).	Degree of implementation of safe practices for the design and use of the ADS.	Mapping of practices little-used or not yet implemented related to the proper use of the ADS.	83.3% of the hospitals had implemented unit dose and/or automated systems. Only 1/3 used the ADS as a single dispensing system. ADS as the main dispensing system and connected to electronic prescription: 36.1% of hospitals that used ADS. Lowest score was for removal of medications from the ADS using the override function (28,4%).	Does not cite response rate and the number of questionnaires sent or validated. However, this Survey draws attention to the configuration of alternative technology and the high risk of the override function, suggesting potential risks of drug errors.	5D
HELMONS PJ, DALTON AJ, DANIELS CE[15] United State of America	Descriptive, before and after. A total of 6829 pockets in 26 ADS and 3855 pockets in 24 ADS were inventoried 5 months before (pre) and 18 months after (post). US medical center with 386 beds.	A filling program connected to the bar-code system. * Scanning prepackaged drugs still in stock provides safe administration.	Medication-refill errors were defined as a pocket or compartment containing the wrong drug or wrong dosage.	Reduction in ADS refill errors = 77%, from 62 errors per 6829 refilled pockets (0.91%) to 8 errors per 3855 refilled pockets (0.21%) (p <0.0001). Type of error: incorrect medication in the ADS drawer (before: n=30; 48% versus after: n=1; 13%). OR:0,23 CI 95% (0.11-0.47)	Discrepancy in collection time (5 months before and 18 months after intervention). However, it signals the potential risk associated with technology and the benefits of using bar-codes not only at the bedside, but from the storage stage, reinforcing the principle of traceability.	2B
RODRIGUEZ-GONZALEZ CG et al.[16] Espanha	Prevalence study. 2314 medication preparations and administration to 73 patients, using ADS, were observed in a 1537-bed hospital in Madrid.	Computerized Physician Order Entry connected to ADS.	Drug administration errors and their potential risk factors.	ME: 509 errors were recorded (22.0%), 68 (13.4%) in preparation and 441 (86.6%) in administration. Most common type: wrong administration techniques (especially concerning food intake (13.9%). Errors were mostly classified as no damage (95.7%).	Does not mention the number of nurses observed or the profile of patients admitted to the units.	4C
SIKKA R et al.[17] United State of America	Descriptive, before and after. Based on medical records and ADS of 951 adult patients with pneumonia admitted to the emergency department of a 700-bed hospital in Chicago.	Alert/lock in antibiotic ADS, preventing dispensing without prior collection of blood cultures and results.	Measure impact on compliance with rational use of antibiotics.	Compliance with obtaining blood cultures prior to antibiotic administration was 84% (205/245, CI95%: 79% -88%) and 95% (275/291, IC95%: 92-97%) in the pre and postintervention periods, respectively (p <. 0.001).	Did not examine the impact of patient demographics, day of the week, time of year, or overcrowding in the unit on compliance with obtaining blood cultures prior to initiation of antibiotics and did not consider a secondary diagnosis of pneumonia or misdiagnosis.	2B

To be continued

Chart 2

Studies	Type of study/ population/ setting	Intervention	Outcomes	Results	Limitations	Oxford
ZAFRA FERNÁNDEZ JL, ISLA TEJERA B, PADRO LLERGO J[18] Spain	Economic assessment, before and after. From April to August 2009 (pre-implementation period) and from April to August 2010 (post-implementation period). 110 questionnaires were sent, with a 63% response rate.	Replacement of traditional drug stocks by the implementation of ADS in the Intensive Care Unit.	Cost reduction and user satisfaction.	Reduction of total costs: 24%. Reduction of costs with personnel: 11%. Reduction of costs with medication: 24%. Increased workload of Pharmacy assistant (increasing from 144 hours to 792 hours per year). Users are satisfied with the implementation and 84% of nurses would recommend it to other units.	Did not measure medication errors to relate to drug cost reductions.	5C
PEDERSEN CA, SCHNEIDER PJ, SCHECKELHOFF DJ[19] United State of America	Survey. A questionnaire was answered by the pharmacy directors of 1439 hospitals. 562 questionnaires were returned and the overall response rate was 40.1%.	ASHP National Survey on Drug Dispensing and Administration.	Survey of dispensing systems and their characteristics over the years.	Used a central unit dose distribution system: 60%. Used combined ADS in their distribution systems: 89%. About 96.2% of the ADS used specific medication profiles for the patients, which involved a verification by the pharmacist prior to drug release. Among the hospitals with ADS, 65.7% used compartments with individually secured lid.	Low response rate. Does not mention the rate of drug errors in the ADS over the years, but points out that the option for compartments with individual lids and limited authorization for withdrawal are increasing needs in the hospitals evaluated.	5D
ÁLVAREZ DÍAZ AM et al.[20] Spain	Prospective cohort. Direct observation of the steps of the medication system by a pharmacist on weekdays for 6 months, in a 1070-bed general hospital in Spain.	The use of ADS with and without computerized prescription and dispensing with unitary dose with and without computerized prescription.	Prevalence of errors in different drug dispensing systems.	2,181 errors were detected among 54,169 opportunities of error. Error rate: stock = 10.7%; Unit dose without Computerized Physician Order Entry = 3.7%; Unit dose with Computerized Physician Order Entry = 2.2%; ADS without Computerized Physician Order Entry = 20.7%; ADS with Computerized Physician Order Entry = 2.9%. OR: 6.72 CI 95% (5.78-7.81) Error rate in the filling of the ADS: 20.7%. The most common type of error was omission of doses, with a 11% rate, and different amount of drug in the ADS, with a 5.6% rate.	Single observer in the field. July and August were excluded from the study without justification. Urgent prescriptions or administrations on Saturdays, Sundays and holidays were not considered.	4C
SERAFIM SAD et al.[21] Brazil	Descriptive. Retrospective review of pharmacy medical records and reports and interviews with 83 professionals - nurses, pharmacists and pharmacy assistants - in an 860-bed university hospital integrated into the Brazilian National Health Service.	Implementation of a computerized drug dispensing system (electronic prescription + dose fractionation machines for unit doses + bar-code systems).	To evaluate the effect on nursing and pharmacy services.	The label was considered legible by 82.8% of the nursing staff (48/58). The system was considered safe by 84.5% (49/58) of the nursing staff and 72.0% (18/25) of the pharmacy staff. Advantages: elimination of manual transcription of prescriptions; increased speed in the process; better identification of doses prescribed by physicians; labels containing all necessary identification; and practicality and safety of optical bar code-based verification of the requested and dispensed medications.	Did not measure medication errors, did not report the total of retrospectively evaluated records, and did not measure the nursing workload after implementing the new technology.	4C

To be continued

Chart 2 (concluded)

Studies	Type of study/ population/ setting	Intervention	Outcomes	Results	Limitations	Oxford
KOWIATEK JG et al.[22] Germany	Descriptive, before and after. Expert panel and audit University of Pittsburgh Medical Center, with 647 beds.	Override monitoring tool to perform random audits and determine nursing compliance.	Assessed the safety of the ADS override process.	Monthly nursing management errors related to override decreased from 1.13 errors in the pre period to 1.07 errors in the post period. The severity of the errors showed no significant changes between the pre and post periods. The severity of the errors showed no significant changes between the pre and post periods.	Does not mention the number of ADS evaluated and the percentage of error in relation to the total number of drugs dispensed.	2B
POVEDA ANDRÉS JL et al.[23] Spain	Economic evaluation, (cost benefit and budget impact). 11 ADS in the Intensive Care Unit and emergency of a University Hospital Complex in Madrid were analyzed.	Implementation of ADS in the emergency and ICU sectors.	Technology implementation cost.	The initial value was 330,557 Euros in 2000 and, at the end of 04 years, it reached 61,964 Euros. Positive benefit/cost ratio 1.95. Savings and global cash flow of 300,525 in 5 years.	Did not address indirect costs with drug errors before and after implementation.	4C
ÁLVAREZ RUBIO L et al.[24] Spain	Descriptive. Emergency of a university hospital in Spain. Data from pre and post intervention reports.	Implementation of ADS in the emergency sector.	Assess cost per patient, cost per drug, and workload.	Increase of workload in the pharmacy service, from 3 to 8.75 hours per week. As for inventory management, there was a total reduction from 797 to only 97 types of drugs in stock (13%). Inventory value recovered: 922.75 Euros.	Did not specify the number of ADS implemented and did not conduct a pilot study to find pre-intervention baseline values for comparison.	4C

Note: ADS – Automated Dispensing Systems; ICU – Intensive Care Unit; CPOE - Computerized Physician Order Entry.

DISCUSSION

Drug administration is recognized as a critical moment when it comes to patient safety. Although the literature points out benefits, such as reducing wrong dose and wrong medication errors[11], the use of the technology evaluated in this study in the medication process led to the emergence of new errors, namely: filling or refilling errors, errors in withdrawal from the cabinet and replacement/override errors[10,14-15,20,22].

Errors associated with refilling and withdrawing medication from the cabinet are closely related to the human factor. National studies[25-27] considered usability as a determining factor for the effective use of medical care equipment, revealing that the user underuses or ignores configurations and/or safety alerts that are essential for the patient drug safety. Thus, the user does not seem to see the ADS as a technological barrier to error, but sees the additional work attributed to the activity.

Drug refilling or allocation errors can be reduced when the ADS and bar-codes are associated from stock to drug administration. In this case, the benefits of the technology add to the human factor, creating alerts for current non-conformities. In other words, in situations where the professional is frequently interrupted and when there is a greater risk of errors in the activity to be performed, this technology inserts triggers or alarms that allow the correct execution and/or planning of the action[28].

Errors due to replacement/override are highlighted due to its severity, as it leads to potential risks of medication errors. This function allows the professional to bypass the software due the need to access a larger number or even another drug near the desired compartment. An error of this kind can be understood as a violation: "a deliberate deviation from an operating procedure, a standard or a rule"[28].

Although deliberate, violations are not necessarily the result of misconduct or intent to cause harm. However, the intentionality in the action of getting a larger number of drugs, in disagreement with what is prescribed, gives the violation a personal, individual character, related to the habit or behavior of the professional, in which there is a potential risk of harm to the patient. Therefore, it needs to be notified to the institution's risk management service[29-30].

The implementation of new technologies in drug dispensing and administration processes has been increasingly recommended by the main patient safety organizations. The use of the ADS is part of the plan of automation of pharmacy services, and the cost reduction can be explained by the greater control and better inventory management that this equipment offers to the institution's logistics and supply center.

Biometric identification and traceability of the entire process seems to be the greatest benefit of this technology, as it allows identifying which professionals have refilled and withdrawn a particular drug from the ADS, as well as whether the drug is still prescribed or has been suspended[2-3]. This information allows detecting non-conformities associated with the return, loss and/or misuse of medication in the institution. This detection, therefore, may be associated with cost reductions.

Cost reduction may be associated with lower costs with personnel, as the use of this technology required hiring more pharmacy technicians and fewer nurses. About 40% of the time

of work of the nursing team in inpatient units is spent in the medication administration process, and nurses can administer up to 50 medications in this period of time[31].

Limitations of the Study

The quality of evidence of the studies included in the meta-analysis should be considered. The results of this meta-analysis showed that there should be caution when deciding whether or not to incorporate the automated dispensing system, although the World Health Organization has reinforced the need to minimize medication errors by incorporating automation technologies in hospital pharmacies. Thus, economic feasibility studies, such as budget impact assessment for example, are required[30].

Contributions to the Area

The cost of labor of the professional categories involved in this discussion was not observed or calculated; however, it is understood that nurses have more time dedicated to direct care to the patient, as they do not develop activities related to the acquisition of the drug in the pharmacy, checking of the prescription and preparation; only the administration phase is their responsibility. Therefore, nurses' work in the use of this technology is paramount and has the goal of ensuring patient safety[31].

CONCLUSIONS

The results of this study may represent a new perspective for addressing drug errors, as it shows that investing in technologies such as the automated drug dispensing system is not enough if there are no investments in the human factor.

The new perspective pointed by the results of this investigation broadens the discussion beyond isolated analysis of the effectiveness of the interventions adopted and the reduction of medication administration errors, especially when the results of the study reveal that there is no statistically significant difference in terms of effectiveness of the technologies evaluated.

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