Impact of barcode medication administration systems on patient safety: a rapid review

Vera Lúcia Vieira Baptista [1]   ⓘ 0009-0003-8704-2835
Ricardo Jorge Garrido Pato [2]   ⓘ 0009-0005-7447-7893
Cecília Patrícia Mota Moreira [3]   ⓘ 0009-0008-0799-8420
Filipe Daniel Gomes Lima [3]   ⓘ 0000-0002-5066-8469
Maria José Lumini [4]   ⓘ 0000-0002-2951-8001

[1] Prelada Hospital, Porto, Portugal.
[2] Pediatric Hospital of the Coimbra Local Health Unit, Portugal.
[3] Porto Blood and Transplantation Center, Portugal.
[4] Porto School of Nursing, Portugal.

ARTICLE INFO

ABSTRACT

Introduction: Patient safety is currently a central concern within healthcare systems. Medication administration represents one of the most critical stages of care delivery, in which the prevention of errors is of utmost importance. The wide variety of available pharmaceuticals, extensive medical prescriptions, and the need for precise medication administration in complex clinical environments make this process particularly susceptible to human error. It is therefore essential to adopt strategies with the potential to reduce such safety incidents, among which the implementation of barcode scanning technology stands out.

Objectives: Evaluate the impact of medication administration through the barcode reading system on patient safety.

Methodology: A Rapid review of the literature was conducted following the Joanna Briggs Institute methodology and PRISMA guidelines, with searches performed in the EBSCOhost database aggregator and the PubMed database. The descriptors were "patient safety", "barcode medication administration" and "medication errors". The inclusion criteria encompassed documents in portuguese or english, with full text available, published between 2020 and 2025. Two independent reviewers conducted screening, data extraction, and quality assessment.

Results: Of the 109 articles initially identified, five were selected for full analysis after applying the inclusion and exclusion criteria. These studies were conducted in several European countries (the Netherlands, Switzerland, and the United Kingdom), North America (the United States of America) and Australia, all in hospital settings (emergency departments, inpatient units, and day hospitals). The included studies demonstrated that the implementation of barcode medication administration systems leads to a significant reduction in medication errors.

Conclusion: Medication administration using barcode reading is a valuable technological innovation, with a significant impact on patient safety. By contributing to the reduction of medication errors, optimizing the accuracy of information and providing a reliable electronic record, this technology plays a fundamental role in preventing events that could cause harm to patients.

Autor correspondente:
Vera Lúcia Vieira Baptista;
Hospital da Prelada,
Porto, Portugal;
verinhabaptista@gmail.com

RESUMO

Introdução: A segurança do utente constitui, atualmente, uma preocupação central dos sistemas de saúde. A administração de medicamentos representa um dos pontos críticos da prestação de cuidados, onde a prevenção de erros assume particular relevância. A ampla diversidade de fármacos disponíveis, as prescrições médicas extensas e a necessidade de uma administração de medicação rigorosa em contextos clínicos complexos, tornam este processo suscetível a erros humanos. Reveste-se, assim, de extrema importância a adoção de estratégias com potencial para reduzir estes incidentes de segurança, destacando-se, entre elas, a implementação da tecnologia de leitura de código de barras.

Objetivos: Avaliar o impacto da administração de medicação através do sistema de leitura de código de barras na segurança do utente.

Metodologia: Foi realizada uma revisão rápida da literatura, seguindo a metodologia do Joanna Briggs Institute e as diretrizes PRISMA. A pesquisa foi efetuada no agregador de bases de dados EBSCOhost e na base de dados PubMed. Os descritores utilizados foram *"patient safety"*, *"barcode medication administration"* e *"medication errors"*.

Os critérios de inclusão foram definidos como documentos em português ou inglês, com texto integral disponível, publicados entre 2020 e 2025. A triagem e seleção dos estudos foram realizadas de forma independente por dois revisores.

Resultados: Dos 109 artigos inicialmente identificados, cinco foram selecionados para análise completa após a aplicação dos critérios de inclusão e exclusão. Estes estudos foram realizados em diversos países europeus (Países Baixos, Suíça e Reino Unido), na América do Norte (Estados Unidos da América) e na Austrália, todos em contextos hospitalares (serviços de urgência, unidades de internamento e hospitais de dia).

Os estudos incluídos demonstraram que a implementação de sistemas de administração de medicamentos por código de barras conduz a uma redução significativa dos erros de medicação.

Conclusões: A administração de medicação por meio de leitura de código de barras é uma inovação tecnológica valiosa, com um significativo impacto na segurança do utente. Ao contribuir para a redução dos erros de medicação, otimização da precisão de informação e fornecimento de um registo eletrónico confiável, esta tecnologia desempenha um papel fundamental na prevenção de eventos passíveis de causar dano ao utente.

Introduction

In recent years, there has been increasing evidence recognizing the importance of patient safety in healthcare.[1] Patient safety constitutes a central concern within modern health systems, and medication administration represents one of the critical and complex stages of care delivery where prevention of errors is of extreme importance. The wide variety of available medications, increasingly complex medical prescriptions and the need for precise and safe administration in demanding clinical settings make this process particularly susceptible to human error.

For conceptual clarity, and in accordance with international patient safety frameworks, it is essential to distinguish between related but distinct concepts frequently used in the literature. A medication error is defined by the National Coordinating Council for Medication Error Reporting and Prevention as any preventable event that may cause or lead to inappropriate medication use or patient harm[2]. An adverse drug reaction, as defined by the World Health Organization (WHO), refers to a noxious and unintended response to a medication occurring at doses normally used in humans and does not necessarily result from an error[3,4,5]. A safety incident or adverse event is defined by the WHO as an event or circumstance that could have resulted, or did result, in unnecessary harm to a patient, encompassing both preventable and non-preventable occurrences[2-5].

The Agency for Healthcare Research and Quality (AHRQ) published a report in July 2020 characterizing medication-related events as the most frequent category of adverse occurrences in a hospital setting which demonstrated that medication-related harms are the most frequent.[2] Similarly, a study published in 2020 in the British Journal of Anaesthesia, which analyzed 7072 incidents found 1970 events directly associated with medication, with the administration phase accounting for the highest frequency of incidents (42%) and the greatest rate of patient harm (44%).[3]

The World Patient Safety Day, promoted by the WHO, adopted the motto, in 2023, "Medication Without Harm", emphasizing the global urgency of reducing medication-

related incidents caused by errors and unsafe practices.[4] This priority is explained in the Portugal National Patient Safety Plan (NPSP) 2021-2026, which establishes clear objectives for preventing and managing patient safety incidents, across the National Health Service (SNS), thereby reinforcing patient safety as undeniable healthcare priority.[5] The diversity of medications, complex prescriptions and the need for precise administration in a clinical environment make medication administration susceptible to human errors. In this scenario, technology emerges as a valuable ally in the pursuit of patient safety.[6] The implementation of policies and strategies aimed at reducing safety incidents, including preventable ones, has been widely acknowledged as a key driver of improvements in health outcomes.[7] Patient safety is an unequivocal commitment in healthcare, and the prevention of errors in medication administration is an essential part of this commitment.[1] Medication administration constitutes a critical and complex component of healthcare provision that requires maximum attention and precision from healthcare professionals, particularly nurses.[8] In this context, and to address this demand for patient safety, various technological innovations have been developed.

Among the technological strategies developed, barcode medication administration (BCMA) systems have gained special prominence.[9] The application of barcodes in medication administration offers the promise of reducing errors, ensuring that the right medication is administered to the right patient, at the right dose and time.[7] This technology has the potential to mitigate risks and elevate safety standards in healthcare institutions.[9] Thus, the opportunity and interest arose to investigate the impact of using the BCMA system on patient safety. Throughout this article, we will explore the relevance, challenges and implications of using these systems in medication administration safety, considering the context of the Portuguese NPSP and the crucial role played by nurses in promoting safe and effective care.

Barcode Medication Administration System

The BCMA process begins with the clinical prescription of the medication, preferably in digital format. The pharmacist, upon accessing the prescription, verifies it and transfers it to the electronic medication administration record. In this system, all medications are dispensed in unit-dose format and have a unique and individual barcode.

During the medication administration procedure, the nurse must scan the barcode on the individually packaged medication provided by the pharmacy, as well as the barcode on the patient's identification wristband. The patient's data (name, date of birth, and medical record number), along with medication data (name, dosage, pharmaceutical form, route of administration, and time of administration), appear on the screen of the barcode scanning device, the Personal Digital Assistant (PDA).

In the event of any discrepancy, the system issues an alert that appears on the PDA screen. By allowing the simultaneous scanning of the patient's and medication's barcodes, the system automatically verifies whether the right medication is being administered to the right patient, at the right time and in the right dose. At that same moment, the administration is automatically and instantly documented in real time. [10]

This system also proves extremely useful for the safe identification of patients with impaired consciousness, cognitive deficits or those who are unable to communicate orally and/or verbally.

The BCMA system uses a color-coded scheme to guide the nurse during the medication administration process:

Red indicates that the medication is being administered outside the scheduled time or is delayed; Yellow refers to medication not yet administered, but still within the scheduled time window; Green indicates that the medication has been successfully administered.

The barcode system can be integrated into the existing information technology infrastructure of the healthcare institution and allows information to be transferred to the documentation standard in use. [11] The PDA is a small, lightweight, portable device that can be easily carried. Its use applies to the validation of different types of medications, being a technology that offers high safety levels in medication administration.

It promotes the reduction of medication administration errors, especially in terms of patient identification, drug identification, and dosage verification, while also significantly reducing both the rate and severity of administration errors.[12]

When the BCMA system is combined with automated unit-dose drug dispensing and a Computerized Physician Order Entry (CPOE) system, it creates a closed-loop medication process, which significantly contributes to the effective reduction of medication administration errors.[13] This system features simplified and standardized procedures, reducing the need for the nurse to travel to the medication preparation room, since the barcode scanning device is portable and can accompany the nurse as they move with the medication cart to the patient.

The use of this technology also results in a reduction in the time needed to record medication administration, as it allows for real-time documentation at the patient's bedside, and for simultaneous validation of the different medications administered.[12]

The BCMA system has been widely implemented in healthcare institutions around the world, and Portugal is no exception.

Methodology

Research question

Considering the national and international context, our objective in this review is to assess the actual impact that medication administration using a barcode scanning system has on patient safety. Therefore, using the PICO acronym, we formulated the following research question: *What is the impact of medication administration using a barcode system on patient safety?*

The proposed rapid review will be conducted in accordance with JBI methodology and reported in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[14,15] In Table 1, we present the breakdown of our research question.

Table 1. PICO question breakdown.

Population	Intervention	Comparison	Outcomes
Hospitalized patients	Medication administration using the BCMA system	Medication administration without the BCMA system	Occurrence of errors

Search strategy

To address the research question in this rapid review, the following methodological steps were undertaken:

1. A preliminary search to identify and select the most frequently used MeSH terms relevant to the topic;
2. A comprehensive search for relevant studies;
3. Study selection;
4. Data extraction and analysis;
5. Presentation and discussion of findings.

The final search was conducted on Dezember 14, 2025, using the EBSCOhost database aggregator and the PubMed search engine. The selected MeSH terms were: "Patient Safety", "Barcode Medication Administration" and "Medication Errors".

In the EBSCOhost search, to narrow down the results, it was specified that "Barcode Medication Administration" had to appear in the title of the article. This decision was made due to the broad indexing of nursing and health technology journals within EBSCOhost, where preliminary exploratory searches retrieved a high number of non-specific results when the term was searched across all fields. Restricting the term to the title increased specificity and ensured the inclusion of studies with a primary focus on BCMA. On PubMed, the term "medication errors" was included to further restrict and refine the search. Given PubMed's extensive biomedical scope and MeSH-based indexing, the inclusion of "medication errors" allowed the identification of studies specifically addressing patient safety outcomes related to medication administration, while reducing the retrieval of studies focused exclusively on dispensing, prescribing or pharmaceutical logistics.

Although these differences in search strategy may have influenced the number and type of records retrieved in each database, they were deemed necessary to balance sensitivity and specificity and to ensure alignment with the review's objective of assessing the impact of BCMA on medication administration safety. The search terms were combined using the Boolean operator AND, and a publication date limit from 2020 to 2025 was applied.

The complete search strategy is outlined in Table 2.

Table 2. Search strategy.

Database	Fields	Search Terms	Filters
EBSCOhost	TI (Title)	"Patient Safety AND Barcode Medication Administration (TI) AND Nursing Practice	Full text 2020–2025 English / Portuguese Study type: not restricted
PubMed	Title/Abstract + MeSH	Barcode Medication Administration (Title/Abstract) AND Medication Errors (MeSH Terms)	2020–2025 Humans English / Portuguese

Inclusion and exclusion criteria

Considering the nature of the research question and the objectives defined, the following inclusion criteria were applied: articles published in Portuguese or English; full-text availability; publication date between 2020 and 2025.

The timeframe was selected based on the fact that BCMA systems represent an emerging technology that is still in the early stages of implementation in many healthcare settings in Portugal. The five past years correspond to the period during which this technology began to be adopted in some national hospitals. Studies primarily focused on medication prescribing or computerized physician order entry systems, without a specific emphasis on the medication administration process, were excluded, as they did not align with the scope of this review.

Data extraction

Following the database searches and the removal of duplicate records, two reviewers independently screened the titles and abstracts of retrieved articles to identify those most relevant to the research question. Subsequently, after full-text retrieval, three reviewers independently assessed the studies against the predefined inclusion criteria, resulting in the final selection of eligible articles. All bibliographic references were managed using Zotero reference management software.
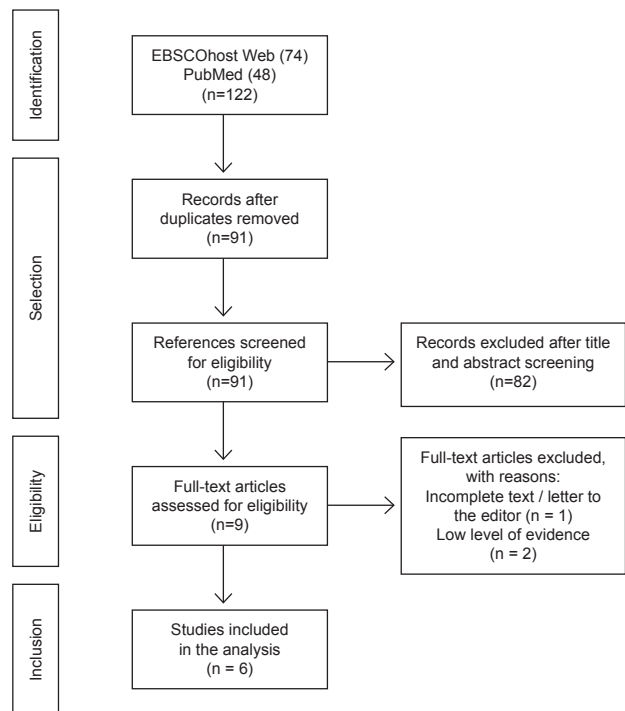
Levels of evidence and methodological quality assessment

The classification of scientific evidence and the assessment of the methodological quality of the selected studies were conducted in accordance with the guidelines of the Joanna Briggs Institute (JBI).[16] The "Checklist for Quasi-Experimental Studies" and the "Checklist for Randomized Controlled Trials" were used depending on the design of each study.[17] The evaluation of the studies was performed independently by two reviewers.

Results

Following the search using the constructed Boolean phrase, a total of 109 publications were retrieved. Of these, 18 were excluded due to duplication. After screening the titles and abstracts, 82 publications were excluded for not addressing the research question. Nine studies were deemed eligible; however, after full-text review, four were excluded: two for not presenting a complete study and two for demonstrating low methodological quality. As a result, the present review includes a total of five studies.

The study selection and inclusion process, based on the defined inclusion and exclusion criteria, is illustrated in the flow diagram below (Figure 1).[15]

Figure 1. PRISMA Flow Diagram of study selection.

The final review includes five studies conducted in European countries (The Netherlands, Switzerland, and the United Kingdom), North America (the United States of America) and Australia. All studies were carried out in hospital settings, including emergency departments, inpatient units and day hospitals. The studies were conducted between 2020 and 2024, with varying durations. Their key characteristics and main findings are summarized in the tables that follow.

Table 3. Listing and characterization of included studies.

Autors	Year of publication	Title	Country	Study design	Area	Administration Number	Results	Medication administration errors	Evidence level	Methodological quality
Owens et al. [9]	2020	The Effect of Implementing Bar-Code Medication Administration in an Emergency Department on Medication Administration Errors and Nursing Satisfaction	United States of America	Comparative study	Emergency Department	1332 medication administrations	Benefit of BCMA in reducing medication administration errors and improving nurse satisfaction.	Wrong dose (2.96%)	3	6/9
Kung et al. [11]	2021	Effect of barcode technology on medication preparation safety: a quasi-experimental study	Switzerland	Quasi-experimental	2 medical-surgical inpatient units	5932 selection and dosage criteria	BCMA reduced the rate of medication preparation errors. Relative risk reduction of 54.5%	Wrong medication (OR 0.38, P = 0.010) and wrong dosage errors (OR 0.12, P = 0.004). Wrong patient,	2	8/9
Barakat & Franklin [12]	2020	An evaluation of the impact of barcode patient and medication scanning on nursing workflow at a UK teaching hospital	United Kingdon	Comparative study	2 cirurgical ward units	459 medication administrations	BCMA allowed the positive identification of 100% of patients. The high rate of adherence to scanning prior to drug administration makes it possible to identify prescription errors before administration.	Wrong formulation (0.4%)	3	7/9
Jessurun et al. [13]	2021	Effect of automated unit dose dispensing with barcode scanning on medication administration errors: an uncontrolled before-and-after study	Netherlands	Uncontrolled prospective study	6 medical ward units	3120 medication administrations	The implementation of automated central dispensing of unit doses with BCMA was associated with a lower likelihood of medication administration errors.	Wrong administration Technique (99) Wrong medication handling (59)	3	8/9
Tan et al. [18]	2024	The impact of barcode-assisted medication administration on medication administration errors in non-unit-dose settings	Australia	Systematic review	3 medical ward 1 surgical ward	12013 medication administrations	The systematic review included 4 studies in non-unit-dose settings and found weak to moderate evidence that Barcode-Assisted Medication Administration (BCMA) reduces certain categories of Medication Administration Errors (MAEs).	Omission of doses, wrong diluent and the fast administration	3	9/10

Discussion

Medication administration constitutes a central and particularly sensitive stage of healthcare delivery and is widely recognized as a priority domain of patient safety due to its technical, cognitive, and organizational complexity.[3-5] Within this context, it should be noted that studies primarily addressing medication prescribing or order entry systems were outside the scope of this review, which focused exclusively on the administration phase of the medication-use process.

Available national data reveal a consistent increase in the reporting of medication-related incidents in recent years, reflecting both the persistence of risks throughout the medication-use process and a growing institutional awareness of patient safety.[4] Within this context, the administration phase emerges as one of the most vulnerable stages, as it relies heavily on the direct interaction between nurses, patients, and clinical decision-support systems.

Although barcode medication administration systems are already implemented in some Portuguese hospitals, the literature searches conducted for this review did not identify any peer-reviewed studies published in Portugal during the defined timeframe. This scarcity of national evidence justified the focus on international studies and limits the direct extrapolation of findings to the Portuguese context.

In the absence of a BCMA system, nurses must manually ensure that the medication, dosage, pharmaceutical form, administration method, and timing are correct, as well as, accurately identify the patient. This manual identification process increases the risk of error, especially for patients with impaired consciousness, cognitive limitations or an inability to communicate verbally.

Several studies validated the advantages of BCMA systems in reducing medication errors and optimizing nurses time, while also acknowledging some limitations. A quasi-experimental study by Kung et al.[11] conducted in a Swiss hospital demonstrated a 54.5% reduction in total

medication preparation errors following BCMA implementation, including significant decreases in errors related to patient identification, medication, dosage, and pharmaceutical form. No patient misidentification or incorrect pharmaceutical form errors occurred during the study, and the highest observed error rate was below 0.4%. Additionally, nurse preparation time was reduced by 38%. However, some errors related to dose omissions, preparation of non-prescribed medications and incorrect dosing in unit-dose drawers persisted, partly due to human, technical or logistical factors, including lack of interoperability between information systems. Jessurun et al.[13] conducted a prospective study in a Dutch hospital showing BCMA implementation reduced medication administration error probability from 19.5% to 15.8%, with potentially harmful errors occurring in only 0.3%. Errors related to omissions, non-prescribed drugs, incorrect pharmaceutical forms and wrong doses also decreased significantly compared with the pre-intervention period.

Barakat and Franklin[12] highlighted that BCMA no only improves patient and medication identification but also optimizes nurses working time. Their United Kingdom (UK) study found that nurses using BCMA administered more doses in similar or less time compared than those without the system, achieving a 100% patient validation rate via PDA. Owens et al.[9] reported that the implementation of BCMA resulted in a 74.2% reduction in medication administration and patient misidentification errors, with nurses also expressing higher perceptions of safety and greater satisfaction with the system. The most persistent errors were related to partial dose administration, leading Owens et al.[9] to recommend additional packaging options to enable more precise dosing.

Additionally, nurses may occasionally bypass BCMA procedures to simplify workflow, such as scanning incorrect patient barcodes, reducing system effectiveness. [12,13] At the mentioned institution, initial resistance, especially among older nurses, was overcome through strong management support and the demonstration of clear benefits. Some medications (e.g., insulin pens, ointments) cannot be scanned or partial doses cannot always be accurately recorded. Offline contingency plans are therefore essential in the event of power outages or cyberattacks; at the institution in question, a 24-hour prescription history is stored for offline access.

The evidence analyzed in this rapid review indicates a general consensus regarding the potential of BCMA systems to mitigate medication administration errors, albeit with heterogeneous results that are strongly dependent on the context of implementation. Studies conducted across different clinical settings demonstrate significant reductions in errors related to patient identification, wrong medication, incorrect dosage, and administration of non-prescribed medications following BCMA implementation.[9,11,13] These findings are consistent with those reported by Poland et al.,[1] who

emphasize the role of BCMA as an additional safety barrier within the medication administration process, particularly in settings characterized by high workload and organizational complexity.

However, a critical appraisal of the evidence reveals that the benefits of BCMA are neither uniform nor absolute. Tan et al., included in this review, is particularly relevant, as it demonstrates that in contexts lacking unit-dose dispensing systems, the available evidence is characterized by limited methodological quality and inconsistent outcomes. The authors report modest reductions in certain categories of error, alongside a lack of significant impact in others, particularly errors related to timing of administration, underscoring that BCMA alone is insufficient to ensure robust and sustained gains in patient safety.[18]

Several studies identify structural limitations that constrain the effectiveness of BCMA systems. Barakat and Franklin demonstrate that despite clear improvements in patient identification and traceability of medication administration, challenges persist in relation to system interoperability, time management, and the adaptation of clinical workflows.[12] Similarly, Jessurun et al. report that certain types of errors, such as omissions or inappropriate dose adjustments, continue to occur after BCMA implementation, reinforcing the notion that technology primarily addresses mechanizable errors and has a more limited impact on errors of a cognitive or organizational nature.[13]

The literature also highlights the recurrent and critical phenomenon of workarounds. The study published in the *Canadian Journal of Nursing Informatics* describes informal strategies adopted by nurses to circumvent technical constraints, time pressures, or system failures, such as scanning barcodes away from the point of care or retrospectively validating administrations that have already occurred. Although often motivated by intentions to maintain efficiency or continuity of care, these behaviors undermine the safety potential of BCMA systems and point to the need for approaches centered on safety culture and alignment between system design and real-world clinical practice.[10] Whereas some studies reported near-complete patient validation rates, workarounds such as retrospective scanning or scanning away from the point of care were also identified.[10,12,13] These practices directly undermine system effectiveness and may lead to an underestimation of residual medication errors. High scanning compliance was associated with greater reductions in error rates, whereas partial adherence attenuated safety gains.[9,11,13]

When analyzed within specific care contexts, the effects of BCMA reveal additional nuances. Owens et al.[9] reported substantial reductions in administration errors and increased nurse satisfaction in an emergency department, while Gow et al.[7] demonstrated significant improvements in adherence to insulin administration timing in acute care units. These findings suggest that BCMA may be particularly impactful in

high-risk, time-pressured environments, provided that adequate training is ensured and the system is functionally integrated into care workflows.

From a methodological perspective, it is important to acknowledge that most included studies present significant limitations, including uncontrolled before–after designs, lack of randomization, and susceptibility to the Hawthorne effect, as outlined in the methodological guidance of the Joanna Briggs Institute and the PRISMA 2020 recommendations.[14-16] These limitations constrain the strength of causal inference and reinforce the need for future research employing more rigorous designs and medium- to long-term impact evaluation.

Finally, the literature converges on the relevance of leadership and organizational culture as critical success factors. Kim et al.[19] demonstrate that perceived benefits of medication safety systems positively mediate the relationship between transformational leadership and the medication error management climate, underscoring the strategic role of nursing leadership in promoting adherence, incident reporting, and continuous improvement. This perspective aligns with national patient safety strategies, which emphasize "medication without harm" as a strategic priority of the National Health Service.[4,5]

Overall, the analyzed evidence supports the conclusion that Barcode Medication Administration systems constitute a relevant tool for improving patient safety in medication administration, particularly in preventing identification and administration errors. However, their effects are context-dependent and influenced by digital maturity, professional training, and organizational culture, and they should not be regarded as a standalone solution. BCMA must be embedded within a systemic and critical approach to medication safety, centered on care delivery, the patient, and the nurse as a clinical decision-maker, thereby reinforcing the quality and safety of healthcare provision. This variability in outcomes is further reinforced by studies examining contextual and organizational factors. Hong et al. [6] warn of the risk of "disappearing clinical expertise" in highly automated environments when technology is adopted uncritically, potentially leading to excessive system dependence and reduced active clinical surveillance by nurses. This tension between automation and professional autonomy emerges as a central axis in contemporary discussions on medication safety, highlighting the need for implementation models that value both technological support and clinical judgement.

Conclusion

Patient safety is a core component of healthcare quality and a shared responsibility across all stages of medication administration. Errors in this process represent a significant risk to patient safety, and efforts should focus on implementing evidence-based strategies to reduce their occurrence. BCMA systems have demonstrated potential to mitigate errors related to patient identification, incorrect dosing, and administration of unauthorized medications. By enhancing the accuracy of information, providing reliable electronic records, and supporting standardized administration workflows, BCMA can contribute to safer medication practices and more efficient nursing care. However, the effectiveness of BCMA is context-dependent, influenced by factors such as workflow integration, staff training, system interoperability, and organizational culture. The technology alone is insufficient to ensure comprehensive safety improvements; it must be integrated within a systemic approach that values clinical judgment, supports professional autonomy, and fosters a culture of safety. Future research should focus on rigorous evaluations of BCMA implementation, particularly in different healthcare contexts, to better understand its impact on patient safety and workflow efficiency. Such evidence is essential to guide informed adoption strategies and to optimize the benefits of BCMA in diverse clinical environments.

Data supporting the results will be provided on request.

References

1. Poland H, Black A, Diogo I. Enhancing patient safety by mitigating nursing medication administration workarounds. *Can J Nurs Inform*. 2023;18(1).

2. Agency for Healthcare Research and Quality (AHRQ). *AHRQ National Scorecard on Hospital-Acquired Conditions: Final Results for 2014 Through 2017*. Rockville, MD: Agency for Healthcare Research and Quality*;* 2020.

3. Amaral J. A segurança do doente na prestação de cuidados de saúde: uma prioridade na política de saúde. *Revista Jurídica Luso-Brasileira*. 2023.https://www.cidp.pt/revistas/rjlb/2023/3/2023_03_1693_1778.pdf Accessed 10 october 2024.

4. Serviço Nacional de Saúde (SNS). Medicação sem danos. Publicado em 2022. https://www.sns.gov.pt/noticias/2022/09/19/medicacao-sem-danos/Accessed 10 october 2024.

5. DRE. Despacho n.º 9390/2021, Plano Nacional para a Segurança dos Doentes 2021–2026. *Diário da República*, Série II; 2021.https://www.arsnorte.min-saude.pt/wp-content/uploads/sites/3/2021/09/Plano-Nacional-para-a-Seguranca-dos-Doentes-2021-2026.pdf Accessed 10 october 2024.

6. Hong JY, et al. Disappearing expertise in clinical automation: barcode medication administration and nurse autonomy. *J Am Med Inform Assoc*. 2021;28(2). doi:10.1093/jamia/ocaa135

7. Gow H, et al. Improving the timing of insulin administration in adult acute care patients. *Nurs Health Sci Res J*. 2022;1(5):47-55. doi:10.55481/2578-3750.1141

8. Giraldo L, et al. Exploring nurses' perceptions and expectations toward a BCMA implementation using a mobile app and workstations as a change management strategy. *Stud Health Technol Inform*. 2018:134-138. doi:10.3233/978-1-61499-872-3-134

9. Owens K, et al. The effect of implementing barcode medication administration in an emergency department on medication administration errors and nursing satisfaction. *J Emerg Nurs*. 2020. doi:10.1016/j.jen.2020.07.004

10. Burkoski V, et al. Experiences of nurses working in a fully digital hospital: a phenomenological study. *Can J Nurs Leadersh*. 2019;32:72-85. doi:10.12927/cjnl.2019.25813

11. Kung K, et al. Effect of barcode technology on medication preparation safety: a quasi-experimental study. *Int J Qual Health Care*. 2021;33(1). doi:10.1093/intqhc/mzab043

12. Barakat S, Franklin BD. An evaluation of the impact of barcode patient and medication scanning on nursing workflow at a UK teaching hospital. *Pharmacy (Basel)*. 2020;8(3):148. doi:10.3390/pharmacy8030148

13. Jessurum JG, et al. Effect of automated unit dose dispensing with barcode scanning on medication administration errors: an uncontrolled before-and-after study. *Int J Qual Health Care*. 2021;33(4):1-8. doi:10.1093/intqhc/mzab142

14. Tufanuru C, et al. Systematic reviews of effectiveness. In: Aromataris E, et al., eds. *JBI Manual for Evidence Synthesis*. s.l.: JBI; 2021. doi:10.46658/JBIMES-24-03

15. Page MJ, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*. 2021;372:n71.

16. JBI. *Manual for Evidence Synthesis*. 2021.

17. JBI. Suporting for the Joana Briggs Institute levels of evidence and grads of recommendation. 2014.

18. Tan W, Bingham G, Tong E, Shakibaei Bonakdeh E, Wang W. The impact of barcode-assisted medication administration on medication administration errors in non-unit-dose settings: a systematic review. *J Clin Nurs*. 2025. doi:10.1080/10376178.2025.2588254

19. Kim MS, Seok JH, Kim BM. Mediating role of the perceived benefits of using a medication safety system in the relationship between transformational leadership and the medication-error management climate. *J Res Nurs*. 2020;25(1):22-34. doi:10.1177/1744987118824621