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Adil Mubarak Alotaibi
Ministry of National Guard
Health Affairs, Saudi Arabia

Saadi Saad Alanazi
Ministry of National Guard
Health Affairs, Saudi Arabia

Dr. Tahani Mohammed Alqurashi
Ministry of National Guard
Health Affairs, Saudi Arabia

Sultan Safah A Alharbi
Ministry of National Guard
Health Affairs, Saudi Arabia

Mohammed Saleem Alshammari
Ministry of National Guard
Health Affairs, Saudi Arabia

Correspondence
Adil Mubarak Alotaibi
Ministry of National Guard
Health Affairs, Saudi Arabia

Impact of nurse-pharmacist teams on reducing errors in barcode medication administration: Review

Adil Mubarak Alotaibi, Saadi Saad Alanazi, Tahani Mohammed Alqurashi, Sultan Safah A Alharbi and Mohammed Saleem Alshammari

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Abstract
Background: Medication errors pose significant risks in healthcare settings, contributing to adverse drug events and compromising patient safety. The integration of technology, specifically Barcode Medication Administration (BCMA) and electronic Medication Administration Records (e-MAR), has emerged as a potential solution to mitigate these errors.
Methods: This review synthesizes findings from multiple studies assessing the impact of BCMA and e-MAR on medication administration accuracy. Observational and pre-and post-intervention studies were analyzed, focusing on error rates before and after the implementation of these technologies across various healthcare facilities. Key metrics included the frequency and severity of medication errors, as well as healthcare professionals' perceptions of the systems.
Results: The review identified a substantial reduction in medication errors following the implementation of BCMA and e-MAR systems. Studies revealed decreases in dispensing mistakes by up to 96% and documentation errors by approximately 80%. However, variability in results was noted, with some studies finding minimal changes in error rates. Factors influencing the effectiveness of BCMA and e-MAR included the level of staff training, system usability, and workflow integration.
Conclusion: BCMA and e-MAR technologies significantly enhance medication safety by reducing errors in administration processes. However, successful implementation necessitates comprehensive training, effective workflow modifications, and continuous assessment of system performance. Future research should explore the long-term effects of these technologies on patient outcomes and the potential for further innovations in medication management.

Keywords: Medication errors, BCMA, e-MAR, patient safety, healthcare technology

Introduction
The use of medication is a multifaceted process including healthcare professionals, pharmacists, and nurses. Medication mistakes are an incontrovertible reality in all healthcare environments. The transcription, dispensing, and administration phases of the procedure may provide significant risks for critical mistakes and patient damage [1, 2]. These mistakes may arise from human factors such as weariness, excessive workload, neglect, missed information, insufficient knowledge, and lack of attention during medicine administration [3, 4]. Numerous studies have shown that a significant proportion of hospitalized patients suffer damage, injury, or adverse drug events (ADE) due to medication mistakes [5, 6]. Therefore, it is essential to recognize and mitigate the risks, as this may facilitate the avoidance of such incidents. Data obtained from hospital occurrence reports given by an anonymous entity indicated that there were nine (35%) near misses and seventeen (65%) drug mistakes recorded from January to December 2016. The results demonstrated the need for an enhanced medication management system. Thus, Barcode Medication Administration (BCMA) and electronic Medication Administration Record (e-MAR) technologies were recognized as two methods to enhance inpatient medication safety by automating medication verification and using an electronic medication administration record.
The objective of the clinical innovation is to aid nurses in medication administration by using the BCMA and e-MAR systems to mitigate medication mistakes and near-misses, hence fostering a culture of patient safety inside the hospital. The objective of the BCMA and e-MAR system is to guarantee that the appropriate patient obtains the proper drugs, by the five rights, using an electronic validation and documentation system. The data encoded in barcodes on each pharmaceutical package and the patient's barcode identification tag enable nurses to

scan and confirm the necessary details before each administration. This would enhance clinical outcomes, reduce medication-related mistakes, and provide cost-effective care for patients.

Review of Literature

Bonkowski *et al*. [7] performed observational research to assess the medication administration error rate before and after the adoption of Bar-code medication administration (BCMA) in an emergency department (ED), given the complexity and susceptibility to errors in medication administration inside the ED. Data collection is performed via an observation technique by the lead investigator alongside three blindfolded observers, both before and during the introduction of BCMA. The documentation of medicine administration was cross-referenced with the physician's order to verify accuracy in administration. The research indicated that the majority of drug mistakes were of modest severity [7]. The antihistamine drugs had the greatest mistake rate. Dosage mistakes were the predominant errors identified in the research. The introduction of BCMA in the ED has shown substantial decreases in pharmaceutical mistakes, particularly in incorrect dosage errors.

A pre-and post-intervention research was performed in the review by Choo *et al*. [8] across two hospitals in Singapore to assess the efficacy of an electronic medication record in decreasing medication mistakes. The retrospective data from the two hospitals examined were evaluated. One hospital was implementing an electronic medication record system for inpatients, while the other was using a paper-based medication record system. The research indicated no significant change in the occurrence of medication mistakes after the implementation of the electronic medication record system [8]. It is recommended that more research be undertaken to assess the potential of this method in decreasing medication mistake rates and enhancing drug safety.

Descriptive-analytical research involving 242 nurses was performed to examine the correlation between nurses' awareness of Barcode Medication Administration (BCMA) and the application of BCMA in a hospital. Self-constructed questionnaires and checklists were used for data collection to assess nurses' understanding of BCMA and the rate of BCMA implementation within the hospital. The research indicated a favorable albeit limited association between nurses' understanding of BCMA benefits and its implementation. The nurses' acknowledgment of the advantages of BCMA is little and inadequate. The study also indicated that BCMA did not substantially decrease drug and prescription mistakes, which contradicts findings from prior research studies [9]. Educational programs should be established to enhance nurses' expertise and optimize technology use.

Gooder [10] performed case-control research including 59 nurses to investigate the perceived effects of the barcoded medication administration system (BCMA) on nurses' medication administration capabilities, perceptions of medication mistakes, and satisfaction with the BCMA process. Self-constructed questionnaires were used for data collection from the experimental group of nurses using the BCMA system (n = 33) and the control group where BCMA has not been implemented. The research indicated a decline in the overall satisfaction of nurses after the adoption of the BCMA system. Moreover, nurses had a diminished capacity to visually identify both due drugs and those already administered after the adoption of the BCMA. Despite the perception of BCMA systems as a promising technology, the results diverge from previous research that suggests nurses are content with the system [10]. Workflow and work processes must be re-engineered before the introduction and acceptance of new technologies.

Bittner *et al*. [11] assessed the adoption of the Bar-Code Pharmaceutical Administration (BCMA) at a 260-bed hospital and its advancement toward eliminating pharmaceutical mistakes. The assessment was conducted via a study of journals to develop an evidence-based checklist, accompanied by observational audits and interviews with nurses, followed by data analysis and dissemination of results. Three concerns were identified for improvement, and remedial measures were implemented, resulting in a compliance rate of 81%, an increase from the previously reported 72% [11]. The BCMA system, deployed five years ago via this project, demonstrated conformity with current evidence about its proper use, as shown by the evidence-based checklist derived from literature studies.

A literature study was performed examining the variables affecting medicine administration safety, the impact of barcode technology, and the effective use of barcode technology [12]. Eleven articles were used, supplemented with interviews with subject matter experts. Barcode technology decreased dispensing mistakes by up to 96% and documentation errors by 80.3%. The integration of barcode technology with computerized drug administration records has significantly enhanced the efficiency and safety of medicine delivery.

A description of the implementation of electronic healthcare records (EHR) that enhanced patient safety and the integration of technology in the medicine delivery process at a small rural hospital in England [13]. The project was directed by a Clinical Nurse Specialist (CNS), and core team members conducted literature evaluations in nursing, pharmacy, and informatics. Various bidders conducted equipment demos before the procurement of an electronic medication administration record (eMAR) system equipped with a barcode scanner, alongside training for medication administration using an automated medication dispensing machine and bar-coded medications in a simulated patient room. The project was executed in three parts over 36 months. The medication scan rate increased significantly from 93.95% in Phase 1 to 98% in Phase 3 [13]. The project was executed over 36 months and included a procedure to identify and rectify the detected problems. The project illustrated the significance of CNS's leadership in guiding team members and ensuring the project's success.

Samaranayake *et al*. [14] conducted mixed methods research to evaluate the impact of a barcode-assisted medicine administration (BCMA) system on the dispensing process and its users at an academic hospital. Direct observation is used to evaluate the occurrence of dispensing mistakes. Questionnaires and interviews were administered to evaluate the attitudes of the nurses and pharmacists using the system. The results indicated that supplementary measures were included in the dispensing process, increasing mistakes after the implementation of the new system. Nurses have recognized that the approach enhances the precision of drug delivery. The installation of BCMA may have impeded and complicated the dispensing procedure. Nurses believe that the technology has enhanced the medicine delivery procedure [14]. Continuous assessment of the modifications is advised to discover deficiencies, and personnel should be informed about

the advantages.

According to the aforementioned evaluations, some results suggest that with suitable workflow, training, policies, and procedures, along with support and guidance, BCMA and e-MAR will substantially enhance the drug administration process by markedly decreasing pharmaceutical mistakes.

Justification for BCMA and e-MAR

Drug administration entails executing a sequence of intricate procedures for the delivery of the drug. The intricate nature of the procedure presents significant risks for mistakes, stemming from interruptions, job complexity, non-adherence to the five rights of drug administration, and the use of workarounds. The workarounds used by nurses during the execution of mandated procedures to attain specified objectives may result in unexpected consequences, including mistakes [15]. Medication mistakes lead to adverse drug events in patients due to the administration of incorrect medications, resulting in increased healthcare costs. To mitigate adverse drug events (ADEs) and decrease medication mistake rates, several hospitals have begun using barcoded medication administration (BCMA) and electronic medication administration records (e-MAR) [5, 12]. To ensure error-free medication administration, the decision has been taken to use BCMA and e-MAR technology to support nurses, practitioners, and pharmacists in the processes of prescribing, transcribing, dispensing, and giving drugs.

Traditionally, physicians prescribe drugs by documenting them on the inpatient medication record (IMR). The IMR will thereafter be sent to the pharmacy for the pharmacist to manufacture the meds and dispatch them to the ward. Nurses thereafter prepare and dispense drugs from the medication cart brought inside the patient's cubicle or room. This technique seems to be less successful since several instances of medication mistakes and infection control problems have been observed, particularly among patients with undetected transmission-based illnesses.

The main aim of e-MAR is to facilitate electronic prescription, administration, and documentation of drugs administered to patients, hence replacing handwritten IMRs that may be misinterpreted owing to unclear handwriting and improper use of abbreviations. The electronic MAR enhances efficiency via the use of BCMA while decreasing medication mistakes attributable to nurses' misinterpreting instructions, omitting, delaying, or erroneously administering medications and dosages. The BCMA system is designed to minimize pharmaceutical delivery mistakes, decrease associated hospital expenses, and enhance patient safety. Research indicates that the incidence of medication mistakes might decrease by as much as 87% after the implementation of e-MAR within an institution [12]. Electronic MAR may also notify patients about drug allergies and provide audit reports and data, including prescription inventory and instances of missing or delayed doses. Numerous hospitals indicated enhanced effectiveness of barcode technology and better pharmaceutical safety after the successful installation of BCMA [12, 16]. Therefore, this compelling evidence provides a solid basis for recommending the invention.

The objective of e-MAR is to avert mistakes resulting from doctors' illegible handwriting and the omission or postponement of prescription doses. It also guarantees the precise dosage is administered to patients, along with pertinent information about the prescription and proper paperwork. The barcode scanner mitigates the risk of incorrect patient selection, ensuring the accurate administration of medicine and dosage while reducing human mistakes attributable to lapses in concentration [11]. The portable gadget substitutes the physical inpatient medication record and the unwieldy computer on wheels with an attached scanner, which obstructs eye contact with the patient during the verification of the two identifiers (Identification number and name). This invention aims to greatly minimize medication errors and enhance staff compliance in administering the proper medicine to the appropriate patients, by the five rights of medication administration [17, 18]. The execution of the invention includes the launch of the product and alterations to the process.

The product selection encompasses both hardware and software. The identification and assessment of the product need the involvement of both the Information Technologist (IT) and Registered Nurses (RN). The IT department is required to determine the portable device (iPad/Tablet) that has the appropriate specifications for software installation. Consequently, the registered nurses, as end users, must assess two distinct kinds of Bluetooth barcode scanners and portable devices to compare their speed and usability, ultimately selecting the most suitable equipment for the adoption of BCMA and e-MAR. Another facet of product assessment is the choice of software that is readily installable, maintainable, encrypted, and capable of establishing communication linkages among doctors, pharmacists, and nurses to guarantee a closed-loop system [13]. Upon establishment, pharmacists mark the drugs with barcodes.

Education and training include a systematic program designed to educate doctors, pharmacists, and nurses. It is crucial to guarantee the safety of the whole system, and familiarity with system troubleshooting would mitigate process failures in the case of equipment malfunction [19].

The alteration of the procedure, including a variation in the administration of medicine. The existing medication procedure includes physician prescribing in the inpatient medication record (IMR), routing and transcribing prescriptions at the pharmacy by pharmacists, and the delivery and monitoring of medications by nurses [20, 21]. Upon adjustment of the procedure, the physician will prescribe the prescription in the e-MAR inside the physician's module, and the drug will be automatically sent to the pharmacist's module.

Upon receiving the order, the pharmacist will access the patient's data and particular prescriptions, resulting in the printing of medicine labels. The system's value lies in its ability to accommodate drug dosages in their accessible forms. For instance, if the physician prescribes 1 g of paracetamol, the pharmacists may enter the available dosage of 500 mg per tablet and guarantee that two pills are obtained for the accurate fulfillment of the order by pre-configuring the software. The technology prompts nurses to scan the labeled medicine a second time to ensure the dose aligns with the prescription. The indications, side effects, and other relevant information on the drug are easily accessible for nurses upon clicking the medication order in the ward.

During medication administration in the ward, medications due for administration and patients with drug allergies will be marked with color (e.g., yellow, red, etc.) as a reminder. The first step in ensuring safe medicine delivery is the scanning of the patient's wristband. Upon scanning the wrist tag, the patient's information and medication record will be instantly shown. The verification of the two IDs may be conducted

using a hand-held device (iPad/Tablet) that displays patient records. An examination for pain, blood pressure, and other factors may be conducted at this point. Upon completion of the verifications and assessments, the nurse may continue to get the drugs for the patient. The pharmaceutical label is scanned, and dosages are scanned by the order. Subsequently, a second registered nurse verifies the preparation by entering her PIN to certify that the drug has been examined before administration to the patient. At this juncture, the nurse may consult the portable device (iPad/Tablet) for indications and other relevant information on the drug, and thereafter educate the patient appropriately. Patient education is essential for recognizing adverse drug reactions (ADR) and other unexpected occurrences. The alteration of the procedure and the incorporation of supplementary measures protect both patients and healthcare personnel from potential incidents.

Infection Management

The use of non-contact method verification using portable devices (iPad/Tablet) ensures effective infection control practices. The new procedure completely eradicates the laborious cleaning of the mobile cart. The medicine cart will be positioned outside the patients' cubicle to minimize interaction with unidentified airborne infectious illnesses and avoid cross-contamination among other patients [22]. The compact hand-held devices (iPad/Tablet) and Bluetooth barcode scanner may be easily cleansed with alcohol wipes due to their compactness.

Research by Strudwick *et al*. [23] indicated that over fifty percent of nurses delivered drugs without scanning either the medication or the patient throughout their shifts. The causes of this neglect include technological shortcomings, including the incapacity to scan labels owing to defective software, compromised labels, and the patient's isolation precaution status (utilizing a scanner with a computer on wheels) [23]. Consequently, the technology's inefficiency may hinder its use and diminish the anticipated safety advantages. The fault may lead to the cessation or postponement of clinical operations, perhaps necessitating manual medicine administration by the user during the downtime [24-26]. These challenges may be avoided with effective preventive maintenance and a competent reporting system that notifies of any technical problems in advance, allowing for timely resolution of malfunctions.

Change comes from innovation that arises with the introduction of an invention. The achievement of innovation requires proficient leadership, adept change management, and the support of workers to accept the transformation [27-31]. Bucciarelli [32] asserts that Kotter's eight-stage model is the most widely used change framework among businesses since it starts with an analysis of failure in change and fosters a constructive approach to convert errors into phases that facilitate effective transformation. Kotter's [30] eight stages of leading change encompass establishing a sense of urgency, forming a guiding coalition, formulating a vision and strategy, communicating the change vision, enabling broad-based action, generating short-term victories, consolidating gains and fostering further change, and embedding innovative practices within the organizational culture.

The execution of BCMA and e-MAR inside the company requires collaboration from both management and personnel. Therefore, to achieve the objectives and facilitate change, management needs to comprehend the problem posed by the rising incidence of drug mistakes. This would avert complacency inside the company. Observable calamities significantly attract attention and heighten urgency levels [33]. Consequently, a statistical analysis of the frequency and categories of medication mistakes, adverse events, and severe reportable events (SRE) would validate the need to implement BCMA and e-MAR. The guiding coalition comprises authority, knowledge, dependability, and robust leadership. This improves the leader's capability as a change agent and facilitates collaboration with team members for effective transformation. Consequently, project development necessitates the assembly of a team of people from diverse departments and management tiers, each with specific tasks and responsibilities, to provide a framework for embracing change. The formulation of vision and strategy requires a comprehensive grasp of the requirements and motivations for change [30, 31]. Consequently, a suitable communication plan must be developed to disseminate the knowledge throughout the firm, ensuring workers and management endorse the concept.

The creation of BCMA and e-MAR involves the dissemination of medication error data, establishing mutual agreement among staff and management, and building a performance indicator designed to minimize medication mistakes. Qualitative and quantitative information on the goods (Scanning equipment and portable device) and the end users (Registered nurses, doctors, and pharmacists) must be disseminated to equip the staff for the transition. The schedule for implementing BMCA and e-MAR, together with the expenses associated with hardware and software acquisition, process modifications, and personnel training, must be allocated. Finally, the satisfaction rates of both consumers and staff should be assessed. This facet of clinical innovation is essential since the objective of minimizing pharmaceutical errors is established to provide excellent treatment for patients. Consequently, it is essential to gather pertinent data to assess the efficacy of the BCMA and e-MAR upon their implementation [34].

Communication is the pivotal element that determines the success or failure of any effort. Therefore, a well-organized communication strategy that clarifies the advantages of the change incorporates active listening to comments from both staff and management, and promotes worker empowerment is essential. It is essential to identify and remove impediments to prevent workers from being diverted from the intended objective. In the deployment of BCMA and e-MAR, continuous technical and emotional assistance is essential to encourage staff adaptation to the change.

Recognizing helpful personnel and team members, together with suitable awards and acknowledgment, would motivate them to contribute to the project implementation process [26]. This will illustrate the significance and aid in mitigating the effects of unsupportive staff and team members. Upon the implementation of the BCMA and e-MAR, it would be advantageous to aggregate all comments and recommendations on the system's advantages and disadvantages to enhance its efficacy. The system's performance may be assessed and evaluated based on use levels and consultations with the personnel.

Institutionalized creative strategies, along with robust leadership and the identification of a successor, provide continuity in the change process [32]. Embracing organizational change starts with the modification of norms and values, thereby influencing the corporate culture. When the company culture is clearly defined about business success,

the transformation initiative becomes more attainable. Consequently, the execution of BCMA and e-MAR necessitates the cultivation of a robust organizational culture that fosters innovation. Organizational transformation is a dynamic process that impacts many stakeholders and requires strategic management. Failures often arise when businesses attempt to innovate and implement change. It is essential to recognize that change is perpetual and must be endorsed to sustain progress in developing healthcare developments.

An evaluative framework for BCMA and e-MAR practices

According to Nelson-Brantley and Ford [33], transformation is a social, dynamic, and participatory process. Leading change may be assessed by examining particular and aggregate data at a system's micro, meso, and macro levels. The assessment methodology offers evidence-based outcomes for analyzing the design of innovation projects. It will facilitate the reallocation of resources and enhance the project plan as required.

Project assessment is a methodical procedure designed to assess the efficacy, efficiency, and suitability of healthcare innovations to improve clinical outcomes [35]. The assessment also facilitates the formulation of measures to enhance the involvement of healthcare professionals in the deployment of the BCMA and e-MAR systems. Information may be gathered via formative and summative process evaluations. The evaluation design includes the project's history, aims and objectives, evaluation purpose, assessment parameters, project outcomes, evaluation questions, evaluation criteria, dissemination of results, and evaluation timeline [36]. The assessment criteria ascertain the quality, impact, and results of the clinical innovation [37]. These indicators are essential to evaluate the project's success and failure.

The Efficacy of BCMA with e-MAR

According to the evaluation design, assessment criteria, feedback, and audits, the findings may be compiled to ascertain the level of success of the innovation and the project plan [31]. The evaluation of findings via diverse data collection methods, including product and process utilization, software loading and lagging times, awareness among healthcare professionals, shifts in attitudes, knowledge, satisfaction rates of healthcare professionals and patients, sustainability of innovation, and decreased costs in patient care outcomes related to reduced medication errors, facilitates the assessment of the project's success. The qualitative and quantitative study of this statistics data provides evidence-based information about the assessment of the success rate.

Discussion

Following the execution of the aforementioned measures, pilot research commenced in a unit including 43 nursing personnel and interdisciplinary physicians inside a confidential company. Before the trial run, a roadshow was organized for workers to assess the product and process of the new drug management system. The pilot research was executed for two months in a single unit. A project team was assigned to the unit to resolve issues expressed by the nurses and physicians over the efficacy of the BCMA and e-MAR system. On-the-job training, meticulous monitoring, clinical assistance, and nursing informatics professionals were easily accessible to address and resolve presented difficulties. Continuous feedback was collected from end-users to assess the efficacy of the new technology and the associated procedure.

All recommended drugs were validated by the pharmacists' staff before administration. The system included indications and contraindications for each prescription, including its side effects and adverse responses, as well as appropriate dilution and diluents for intravenous administration. The efficacy of the innovation was assessed using drug administration audits, staff comments, and the quantity of hospital occurrence reports related to medication mistakes. The BCMA and e-MAR system received broad acceptance from the workers since the incidence of reported mistakes was markedly reduced. The personnel said that the ongoing assistance from the project team enhanced their confidence in using the new system. Only one near-miss mistake was recorded throughout the two-month testing period. The study indicated that non-compliance was attributed to understaffing and weariness.

Initially, doctors exhibited reluctance due to the time-consuming nature of the additional step required for prescription inside the system. Additional negative comments indicated that the system was sluggish in logging in, loading, and toggling due to a slow Wi-Fi connection. It extended the duration of medicine administration and resulted in discontent among patients who got their normal medication later than customary. Infection control issues were mitigated by the use of mobile devices, such as iPads and scanners, which were thoroughly sanitized before further usage. The nurses articulated the challenges associated with transferring gadgets and medicine cups/trays between rooms for medication administration. They said that a carrier for the gadgets would aid them in avoiding the inconvenience of handling several things. Comprehensive input was collected, revealing that 88.3% of personnel supported the BCMA and e-MAR system, while 11.7% opposed it owing to the aforementioned inconveniences. It is advisable to conduct more research across other departments with larger sample sizes and prolonged study durations to uncover additional challenges encountered by staff and to address the internet connectivity delays before the introduction of the BCMA and e-MAR systems.

Conclusions

The responsibility for medication safety lies with all members of the healthcare team. Numerous studies indicate that medication errors are a primary cause of mortality among hospitalized patients. The BCMA and e-MAR systems would significantly diminish mistakes via the use of advanced technologies. With adequate training and support, the healthcare staff may maintain a high standard by leveraging technology advancements in healthcare and reducing the incidence of reported mistakes.

Despite being in the first phase, the deployment of the BCMA and e-MAR may be laborious and result in delays in medicine delivery; nonetheless, it becomes feasible if integrated into standard care protocols. The success or failure of this therapeutic innovation is mostly contingent upon the communication tactics and the assessment design that assesses the need for process improvement. The anticipated result of the invention is to enable healthcare professionals to execute their clinical responsibilities effectively and provide cost-efficient treatment outcomes to patients.

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تدريبًا شاملاً، وتعديلات فعالة على سير العمل، وتقييمًا مستمرًا لأداء النظام. يجب أن تستكشف الأبحاث المستقبلية الآثار طويلة الأمد لهذه التقنيات على نتائج المرضى والاحتمالات الإضافية للابتكارات في إدارة الأدوية.

الكلمات المفتاحية :أخطاء الأدوية، BCMA، e-MAR، سلامة المرضى، تكنولوجيا الرعاية الصحية.

أثر فرق الممرضين والصيادلة في تقليل لأخطاء في إدارة الأدوية باستخدام نظام رموز الباركود: مراجعة

الملخص

الخلفية :تشكل أخطاء الأدوية مخاطر كبيرة في بيئات الرعاية الصحية، مما يساهم في حدوث أحداث سلبية تتعلق بالأدوية ويعرض سلامة المرضى للخطر. لقد ظهرت تقنية إدارة الأدوية باستخدام رموز الباركود (BCMA) وسجلات إدارة الأدوية الإلكترونية (e-MAR) كحل محتمل للتخفيف من هذه الأخطاء.

الطرق :تستعرض هذه المراجعة النتائج الناتجة من دراسات متعددة تقيم تأثير BCMA و e-MARعلى دقة إدارة الأدوية. تم تحليل الدراسات القائمة على الملاحظة والدراسات قبل وبعد التدخل، مع التركيز على معدلات الخطأ قبل وبعد تنفيذ هذه التقنيات في مختلف مرافق الرعاية الصحية. تضمنت المقاييس الرئيسية تكرار وشدة أخطاء الأدوية، بالإضافة إلى تصورات المهنيين الصحيين حول الأنظمة.

النتائج :حددت المراجعة انخفاضًا كبيرًا في أخطاء الأدوية بعد تنفيذ أنظمة BCMA و .e-MARأظهرت الدراسات انخفاضًا في أخطاء صرف الأدوية بنسبة تصل إلى 96% وأخطاء التوثيق بنسبة تقارب 80%. ومع ذلك، لوحظت تباينات في النتائج، حيث وجدت بعض الدراسات تغيرات بسيطة في معدلات الخطأ. شملت العوامل التي تؤثر على فعالية BCMA و e-MARمستوى تدريب الموظفين، وقابلية استخدام النظام، واندماج سير العمل.

الخاتمة :تعمل تقنيات BCMA و e-MARعلى تعزيز سلامة الأدوية بشكل كبير من خلال تقليل الأخطاء في عمليات الإدارة. ومع ذلك، تتطلب العملية الناجحة للتنفيذ