

## Exploring the Effectiveness of Technology- Based Approaches in Mitigating Medication Errors: A Systematic Review

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### Abstract

*Background: Medication errors are preventable events in healthcare settings, causing inappropriate use or patient harm. They are a major public health concern and can have psychological impacts on staff. They are particularly common in Arab nations and are caused by factors like inadequate knowledge, heavy workloads, poor communication, inconsistent medicine, and lack of safety protocols. Interventions are effective in reducing unexpected errors in administration but not in verification jobs. Strategies to reduce interruption-related errors are needed.*

*Aim: The aim of current literature review is to explore the effectiveness of Technology-based approaches in mitigating medication errors.*

*Method: A systematic search of databases, including PubMed, Scopus and Web of Science, was conducted to classify important studies published between 2019 and 2023. The study requires English-language communication, full-text papers published on technology-based approaches to reduce medication errors. It must include an intervention designed to reduce errors and assess prevention effectiveness. Research older than 2019, non-English, or grey articles is excluded.*

*Results: Within this systematic literature, four subthemes have been identified as electronic based prescription & medial record, blockchain technique, knowledge about the dose of medication and simulation based Learning.*

*Conclusion: It is concluded that electronic bar codes on medication labels and packaging can improve patient safety by encoding medical record numbers. Blockchain technology can track drug transportation, potentially transforming drug supply chains. Barriers to reporting errors include organizational and professional issues. Problem-based learning methodology enhances social, communication, and self-learning skills, but requires human resources and continuous training.*

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## Introduction

Medication errors involve professional practices, goods, processes, and systems such as order communication, product labelling, prescribing, and patient injury. They are avoidable events that result in inappropriate use or patient harm in healthcare settings. One of the biggest causes of death and a serious public health concern is medical error. Patient safety can be enhanced by recognizing and avoiding errors. Errors in healthcare can have psychological impacts on staff members, including melancholy, suicidal thoughts, rage, and guilt. Legal action could have a big impact on these emotions and clinical confidence (Carver, Gupta & Hipskind, 2023; (Alselaml et al., 2023; Alqarni et al., 2023; Shahbal et al., 2022)

Medication mistakes are a major global health risk, and they are particularly common in Arab nations. These mistakes are caused by a variety of factors, such as inadequate knowledge, heavy workloads, poor communication, inconsistent medicine, and a lack of safety protocols. These factors demonstrate the huge disparity in healthcare quality (Elshayib, Abuyassin & Laher, 2021; Almalki et al., 2023)

Medication errors can be caused by interruptions in healthcare settings, and interventions are very efficient at lowering unexpected errors in jobs involving administration. They did not, however, demonstrate uniform efficacy in lowering predictable errors in jobs involving verification. These results enable the adoption of strategies to reduce interruption-related errors in various contexts where drug delivery and verification are necessary (Brunsberg et al., 2019).

Most errors had no therapeutic effect, and the most common sort of error was the incorrect dosage form. The study suggested that in order to fully comprehend the efficacy of the intervention, next research should take into account risk variables such as barcode systems and nursing training (Berdot et al., 2021).

Over the course of more than 780 hours, pharmacists in the study examined around 18000 medications for 6470 individuals—the majority of the more than 500 prescription mistakes intercepted possible harmful pharmacological effects. Antimicrobials, medicines for the central nervous system, anticoagulants, and thrombolytic were the most common mistakes. The costs and advantages of hiring ED pharmacists require controlled trials (Rhee et al., 2019).

Errors of medication, which happen when the incorrect action is performed, such giving medication to someone who has a known allergy, and errors of omission, which come from not acting, are the two main categories of errors (Rodziewicz, Houseman & Hipskind, 2018).

A multidisciplinary pharmaceutical safety team proactively manages risks and problems. Preferably, a pharmacist leads initiatives in accordance with the "ASHP Statement." The role of a pharmacist is essential. In order to lower medication errors and avoid harm, the organizations assess and implement new technology. Decisions about technology ought to engage pharmacists (Series, 2018).

Community pharmacists agree those patient databases, post-registration training, interaction between pharmacist and physicians, inadequate pharmacy facilities, and lengthy working hours are among their top five goals for medication safety (Al Juffali et al., 2019).

Information technologies in hospitals improve drug safety through computerized physician order entry and decision support. Other innovations like robots, bar coding,

automated dispensing devices, and medication administration record computerisation may reduce errors (Rozenblum et al., 2020).

Over the course of four periods, the study demonstrated a decrease in pharmaceutical errors. Common errors were medicine reconciliation, dosage calculations, and needless treatment delays. Over time, some errors went down while others went up. Furthermore, there was a decline in the incidence of possible adverse medication events. According to the study, system optimization is advantageous if it targets some mistake types while lowering others, which could boost patient safety and results (Slight et al., 2019).

Bar-coding has the ability to lower prescription errors in hospitals by eliminating targeted incorrect doses, medications, patients, and routes, according to a study of ten papers on the topic (Hutton, Ding, & Wellman, 2021). Sociotechnical problems in healthcare settings can have unintended consequences, thus it's important to pay close attention to them to guarantee safe implementation and remedial actions (Elshayib & Pawola, 2020).

The purpose of this study was to determine hospital administrators' cost-cutting tactics for pharmaceutical errors. Patient partnerships, open communication, leadership support, multi-layered error prevention, and a culture centred on error prevention were among the themes that emerged from data collected from interviews with ten leaders from high-reliability institutions. Regarding positive social change, the study suggests funding a multilayer error avoidance program and fostering a prescription error reduction culture (Alomari et al., 2020).

According to a study, 17% of actual adverse medication events could have been avoided, while more than 35% were not. Out of the more than 130 medication errors, less than 84% may have resulted in an adverse drug event, whereas only 17% caused an avoidable adverse drug event. Most possible and actual adverse drug events happened during the administration and dispensing phases, with mistakes brought on by omissions, incorrect dosages, incorrect drugs, incorrect administration methods, or interactions between drugs. Comparing the study to other research that used chart reviews and incident reporting, it discovered a higher prevalence of potential and actual adverse medication events (Usak et al., 2020).

Significant differences were discovered in trial techniques, interventions, and kinds of medication errors by the study. While bias was a danger in most studies, most also demonstrated a decrease in mistakes. The results varied from 16% to 100%, with a median reduction between 50 and 70%. Cost-effectiveness needs to be further investigated (Nguyen, Mosel & Grzeskowiak, 2018).

## **Method**

Research Objective:

The objective of the research is to explore the effectiveness of technology- based approaches in mitigating medication errors.

Research Question:

The research questions of this systematic review are following;

- What is the different technology- based approaches in mitigating medication errors?
- How technology-based approaches are effective in preventing the medication errors?

Literature Search Strategy:

A comprehensive and systematic search of academic databases was shown to identify relevant studies published in peer-reviewed journals. The databases to be searched included PubMed, Scopus and Web of Science. The search terms were carefully chosen to encompass relevant concepts, such as "Mitigating medication error," "technology- based approaches " "Effective technology-based approaches"

Table 1: Syntax Search

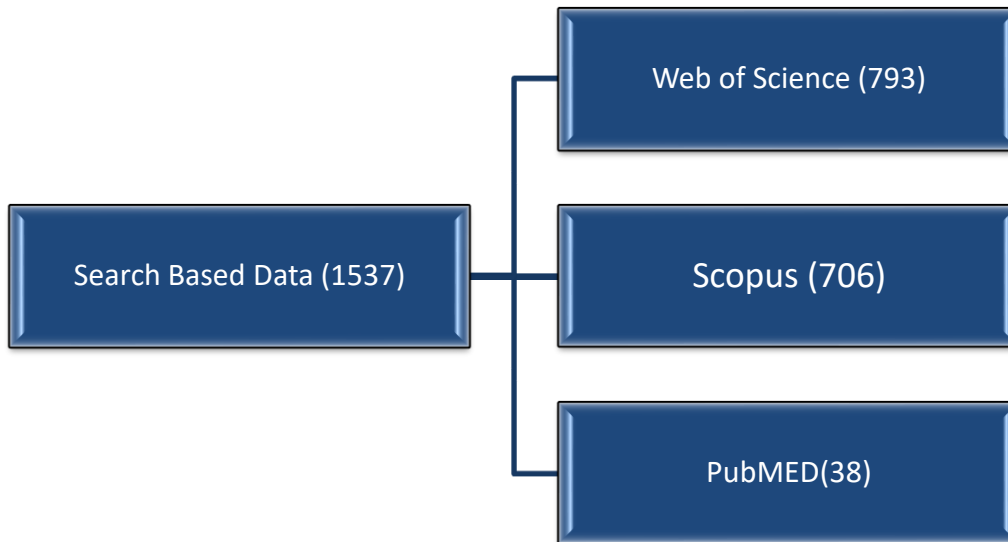
Syntax 1 "Mental health," "Primary healthcare provider," "Gulf countries:"  
 Syntax 2 "Mental health issues," "Mental disorders", "Primary healthcare provider,"

Table 2: Statistics from the Data Base

No	Database	Syntax	Year	No of Researches
1	PubMed	Syntax 1	2019 - 2023	13
		Syntax 2		25
2	Scopus	Syntax 1		156
		Syntax 2		550
3	Web of Science	Syntax 1		437
		Syntax 2		356

The study utilized three databases: Scopus, web of Science, and PubMed to identify relevant research publications between 2019 and 2023. PubMed produced 38 articles, Scopus added 706 and Web of Science added 793, indicating an exhaustive literature search and a strong foundation for the systematic review.

Pictorial Representation of Research Data Base



Inclusion and Exclusion Criteria

The inclusion and exclusion criteria are the fundamental standards for research that show how certain studies are used and how they are not used in this literature review.

Inclusion Criteria

The inclusion requirements include using English-language communications, having full-text papers published between 2019 and 2023, and writing about technology-based approaches for mitigating medication errors. There must be an intervention implemented or reported that is expressly designed to lower the risk of medication errors. There has to be a way to assess how well medication errors were being prevented.

#### Exclusion Criteria

Additionally, all research that does not address the effectiveness of technology based approaches in mitigating medication error, is not written in English literature, is older than the year range of 2019, and uses grey articles for limited edition papers that do not include all the material is excluded from consideration.

#### Quality Assessment

The included studies' methodological quality and bias risk were evaluated using relevant quality assessment tools adapted to various study designs. This process ensured that the research was a compact and trustworthy source of knowledge.

Table 6. Assessment of the literature quality matrix

Sr #	Author	Are the selection of studies described appropriately	Is the literature covered relevant studies	Does the method section describe?	Were findings clearly described?	Quality rating
1	Chang e al.	Yes	Yes	Yes	Yes	Good
2	Ahmad et al.	Yes	Yes	Yes	Yes	Good
3	Alghamdi et al.	Yes	Yes	Yes	Yes	Good
4	Sutherland et al.	Yes	No	Yes	Yes	Good
5	Sarfati et al.	Yes	Yes	Yes	Yes	Good
6	Craig et al.	Yes	Yes	Yes	Yes	Good
7	Jarvill et al.	Yes	Yes	Yes	Yes	Good
8	Mutair et al.	Yes	Yes	Yes	Yes	Good
9	Al-Barnawi et al.	Yes	Yes	Yes	Yes	Good
10	Trakulsunti et al.	Yes	Yes	Yes	Yes	Good
11	Samsiah et al.	Yes	Yes	Yes	Yes	Good
12	Al Rowily et al.	Yes	Yes	Yes	Yes	Good
13	Afaya et al.	Yes	Yes	Yes	Yes	Good
14	Alghamdi et al.	Yes	Yes	Yes	Yes	Good

A sufficient quantity of literature is covered, together with technique sections and detailed descriptions, in the systematic review of studies. The majority of research contains a thorough methods section and clearly articulate the findings, generating the studies a "Good" quality rating.

## Result

### Study Selection

The methodical process of data search includes the identification, formulation, maintenance, monitoring, and synthesis of data. Using inclusion and exclusion criteria, studies are chosen, and search engines are identified. Databases, search engines, and literary libraries are used in research; syntactic input is used for literature searches.

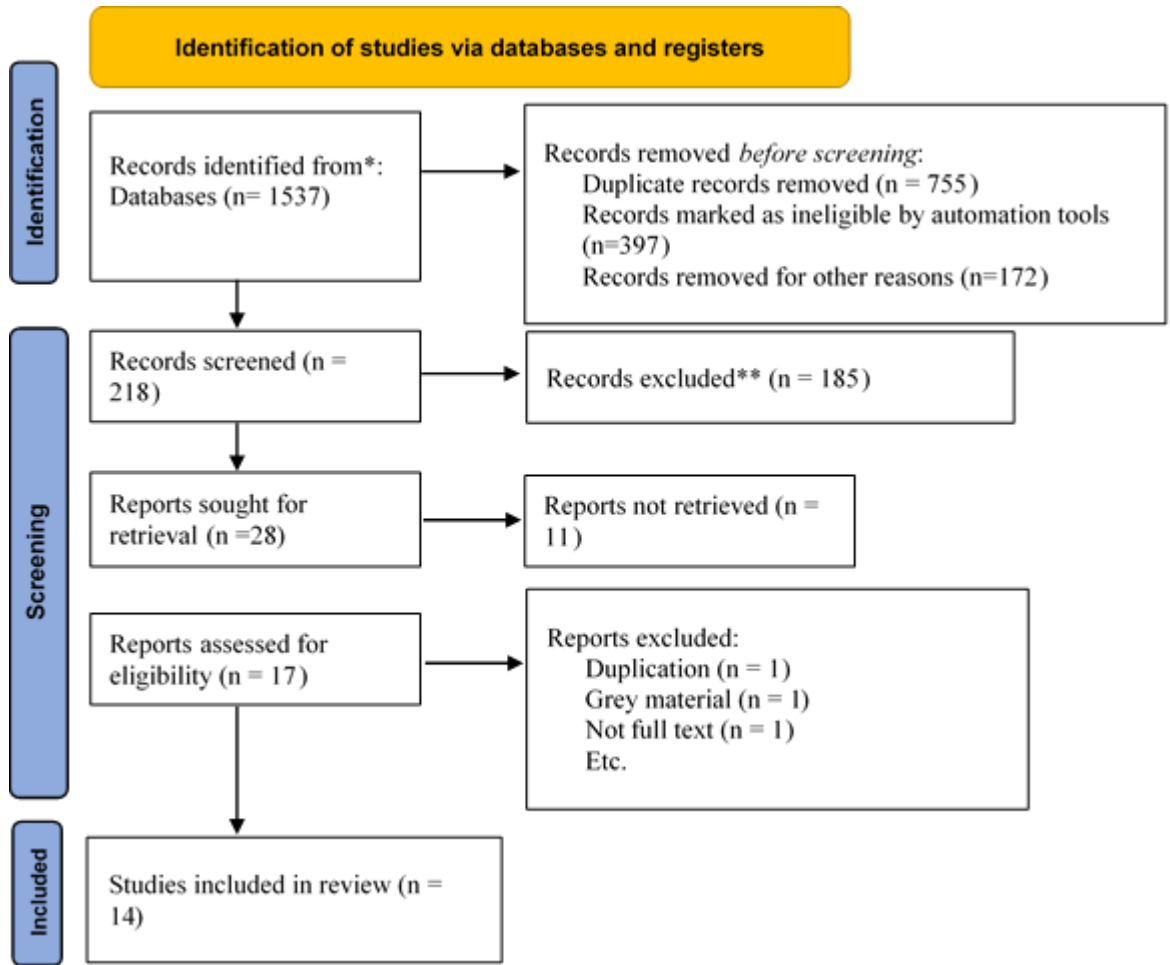
Table 3: Selected Studies for SR (Systematic Review)

No	Author	Research	Year
1	Chang e al.	Changing antibiotic prescribing practices in outpatient primary care settings in China: Study protocol for a health information system-based cluster-randomised crossover controlled trial	2022
2	Ahmad et al.	The role of blockchain technology in telehealth and telemedicine	2021
3	Alghamdi et al.	Prevalence and nature of medication errors and preventable adverse drug events in paediatric and neonatal intensive care settings: a systematic review	2019
4	Sutherland et al.	Incidence and prevalence of intravenous medication errors in the UK: a systematic review	2020
5	Sarfati et al.	Human-simulation-based learning to prevent medication error: A systematic review.	2019
6	Craig et al.	Simulation strategies to increase nursing student clinical competence in safe medication administration practices	2021
7	Jarvill et al.	Effect of simulation on nursing students' medication administration competence.	2019
8	Mutair et al.	The effective strategies to avoid medication errors and improving reporting systems.	2021
9	Al-Barnawi et al.	The effective strategies to avoid medication errors and improving reporting systems	2019
10	Trakulsunti et al.	Reducing medication errors using lean six sigma methodology in a Thai hospital: an action research study	2021
11	Samsiah et al.	Knowledge, perceived barriers and facilitators of medication error reporting: a quantitative survey in Malaysian primary care clinics	2020
12	Al Rowily et al.	Prevalence, contributory factors and severity of medication errors associated with direct-acting oral anticoagulants in adult patients	2021
13	Afaya et al.	Improving patient safety through identifying barriers to reporting medication administration errors among nurses: an integrative review	2021
14	Alghamdi et al.	A mixed-methods analysis of medication safety incidents reported in neonatal and children's intensive care.	2021

Identification of studies via databases and registers

By evaluating research methodology, study quality, and the quality of the chosen study, quality evaluation is a technique used to solve literary difficulties. It makes use of data from the literature, peer-reviewed journals, overall evaluation, and quality management

Table 4: Identification of Studies via Database



Data Extraction

Extracting data requires using a tool with specific inclusion and exclusion criteria. These goals provide complete details on the empirical evidence and specifics about the chosen scholars. The extracted data included study characteristics (e.g., authors, year of publication, study design), participant characteristics (e.g., sample size, healthcare profession), and measures used to assess effectiveness of technology-based approaches in mitigating medication errors.

Table 5: Research Matrix

Author, Year	Aim of Study	Methodology	Sample	Setting	Result
Chang, Y., et al. (2022)	Investigate the impact of a health information system on changing antibiotic prescribing practices	Health information system-based cluster-randomized crossover controlled trial	A total of 320 outpatient physicians	Outpatient primary care settings in China	AI techniques and an educational intervention will be used in this study to effectively reduce antibiotic prescription rates and antibiotic irregularities. This

					study will also provide new ideas and approaches for further research in this area.
Ahmad, R. W., et al. (2021)	Examine the role of blockchain technology in telehealth and telemedicine	Case study method	Not specified	KSA	Blockchain technology can improve telehealth and telemedicine services by offering remote healthcare services in a manner that is decentralized, tamper-proof, transparent, traceable, reliable, trustful, and secure. It enables health professionals to accurately identify frauds related to physician educational credentials and medical testing kits commonly used for home-based diagnosis.
Alghamdi, A. A., et al. (2019)	Investigate the prevalence and nature of medication errors in pediatric and neonatal intensive care	Systematic review	Pediatric and neonatal intensive care settings	KSA	in both settings, prescribing and medication administration errors were found to be the most common medication errors, with dosing errors the most frequently reported error subtype. Preventable adverse drug event rates were reported in three paediatric intensive care unit studies as 2.3 per 100 patients (n = 1) and 21–29 per 1000 patient-days (n = 2). In neonatal intensive care units, preventable adverse drug event rates from three studies were 0.86 per 1000



					doses (n = 1) and 0.47–14.38 per 1000 patient-days (n = 2). Anti-infective agents were commonly involved with medication errors/preventable adverse drug events in both settings.
Sutherland, A., et al. (2020)	Examine the incidence and prevalence of intravenous medication errors in the UK	Systematic review	MEDLINE, Embase, Cochrane	UK	Five of eight studies used a comparable denominator, and these data were pooled to determine a weighted mean incidence of 101 intravenous medication errors per 1000 administrations (95% CI 84 to 121). Three studies presented prevalence data but these were based on spontaneous reports only; therefore it did not support a true estimate. 32.1% (95% CI 30.6% to 33.7%) of intravenous medication errors were administration errors and ‘wrong rate’ errors accounted for 57.9% (95% CI 54.7% to 61.1%) of these.
Sarfati, L., et al. (2019)	Investigate human-simulation-based learning to prevent medication errors	Systematic review	Medline from 2000 to June 2015,	KSA	Properly regulated simulation is a good way to train staff in events that happen only exceptionally, as well as in standard daily activities. By integrating human factors, simulation seems to be effective in preventing iatrogenic risk

					related to ME, if the program is well designed.
Craig, S. J., et al. (2021)	Evaluate simulation strategies to increase nursing student clinical competence in medication admin.	Quasi-experimental study	Nursing students	USA	Found increased clinical competence in safe medication administration practices. tudents who received the medication safety enhancement intervention performed significantly better in a subsequent simulation than students who did not have prior simulation experience (p < .001). Findings suggest that educators should consider high fidelity simulation as an evidence-based teaching strategy to engage students in understanding and implementing medication safety practices in the clinical setting
Jarvill, M., et al. (2018)	Assess the effect of simulation on nursing students' medication administration competence	Not specified	Nursing students	UK	Found positive effects on nursing students' medication administration competence.
Al-Barnawi, A., et al. (2019)	Investigate the relationship between electronic medical records and risk management in Saudi hospitals	A two-phase case study was conducted.	Systems Theoretic Accident Modelling and Processes (STAMP) risk management technique	Hospitals in Saudi Arabia	The first phase implemented the STAMP technique to identify and manage risks to the system. For the second phase, the STAMP technique was extended to include a checklist, to increase STAMP's capability to mitigate risks,

					and the process reapplied. The results demonstrated that the inclusion of the STAMP Checklist reduced errors and prevented system failures compared to regular STAMP.
Trakulsunti, Y., et al. (2021)	Reduce medication errors using Lean Six Sigma methodology in a Thai hospital	Action research study	Not specified	Thai hospital	Specific results are not provided in the summary.
Samsiah, A., et al. (2020)	Examine knowledge, perceived barriers, and facilitators of medication error reporting in Malaysia	Quantitative survey	376 Participants 7 Primary care clinics in Malaysia	In Malaysia.	Found insights into knowledge and barriers related to medication error reporting in Malaysian primary care clinics. The mean score of knowledge was significantly higher among prescribers and pharmacists than nurses, pharmacist assistants and assistant medical officers ( $p < 0.05$ ). A heavy workload was the key barrier for both nurses and assistant medical officers, while time constraints prevented pharmacists from reporting medication errors. Family medicine specialists were mainly unsure about the reporting process
Al Rowily, A., et al. (2021)	Investigate the prevalence, contributory factors, and severity of	Systematic review and meta-analysis	Adult patients	KSA	There is a need to promote multidisciplinary working, guideline-adherence, training,

	medication errors with DOACs				and education of healthcare professionals, and the use of theory-based and technology-facilitated interventions to minimise errors and maximise the benefits of DOACs usage in all settings.
Afaya, A., et al. (2021)	Improve patient safety by identifying barriers to reporting medication administration errors among nurses	Integrative review	Nurses	KSA	Identified barriers to reporting medication administration errors among nurses. The main themes and subthemes identified as barriers to reporting medication administration errors after the integration of results from qualitative and quantitative studies were: organisational barriers (inadequate reporting systems, management behaviour, and unclear definition of medication error), and professional and individual barriers (fear of management/colleagues/lawsuit, individual reasons, and inadequate knowledge of errors).
Alghamdi, A. A., et al. (2021)	Analyze medication safety incidents reported in neonatal and children's intensive care	Mixed-methods analysis	Neonatal and children's intensive care settings	KSA	Found insights into medication safety incidents reported in neonatal and children's intensive care. Common contributing factors to harmful incidents included staff-related factors

					(68.7%), such as failure to follow protocols or errors in documentation, which were often associated with working conditions, inadequate guidelines, and design of systems and protocols.
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Following themes have emerged from the literature review:

Technology- Based Approaches in Mitigating Medication Errors	
1.	Electronic based Prescription and Medial Record
2.	Block chain Technique
3.	Knowledge about the Dose of Medication
4.	Simulation based Learning

### Discussion:

According to the themes extracted from the literature review, the electronic bar codes on medication labels and packaging can enhance patient safety by encoding a patient's medical record number (MAR) into a hospital's information system and allowing nurses to scan the wristband and drug bar code during medication administration (Lou et al., 2022). Electronic based prescription and medical record prevent the medication errors. Electronic prescription may generate the medicine according to the symptoms and physiological factors as weight and age. The study finds that staff-related problems, insufficient guidelines, and system design are major variables that lead to pharmaceutical safety mishaps in neonatal and pediatric critical care. To manage risks, the STAMP technique was used, and to cut down on errors and stop system failures, a checklist was introduced (Alghamdi, 2021 & Al-Barnawi, 2019).

Also, Blockchain technology offers a safe, transparent, and unchangeable way to track the transportation of drugs, which has the potential to completely transform drug supply chains. Additionally, by automating drug tracking and reporting, it can save costs and increase supply chain efficiency. Additionally, by providing decentralized, tamper-proof, traceable, dependable, and secure remote healthcare services, blockchain can improve telehealth and telemedicine services. Additionally, it can assist in locating frauds involving medical testing kits and doctor credentials (Ahmad et al., 2021)

As the study identified barriers to reporting medication administration errors among nurses, including organizational and professional barriers. Medication errors are the number-one error in healthcare, requiring good decision-making skills and clinical judgment. To ensure safe practice, nurses must follow agency policies, follow guidelines for safe medication administration, and ensure full understanding of its implications for patient safety (Afaya et al., 2021 & Al Rowily et al., 2021). The range of medication levels in the blood that are beneficial to health but not hazardous is known as the therapeutic range. Depending on the medication, testing may be required to determine the starting dosage and to regularly check for side effects (Mohanna, Kusljic & Jarden, 2022)

However, Problem-based learning methodology is an effective and satisfactory medical education method, enhancing social, communication, problem-solving, and self-learning

skills. It is more effective than traditional methods and improves knowledge retention and academic performance. However, it requires more human resources and continuous training for widespread implementation (Trullàs et al., 2022 & Pol-Castañeda et al., 2022). In nursing degree programs, simulation is a useful technique for improving medicine administration abilities and bridging the theory and practice gaps. With gender variance, it enhances self-awareness, confidence, clinical performance, and efficiency. The effectiveness of simulation is perceived more favorably by female pupils, which makes it a useful teaching tool (Alshutwi et al., 2022).

### **Limitation & Implication**

This systematic review, focusing on published papers, may be limited by publication bias and the lack of unpublished or grey material. Additionally, technology-based approaches to reducing medication errors are limited, as there are other methods available. Future research should use unpublished data, reports, and expert consultation to identify factors associated with medication errors and explores effective technology-based approaches in healthcare settings, given limited resources for minimizing errors and maximizing patient treatment.

### **Recommendations**

It is recommended that future researchers explore the factors associated with medication errors. Also, there is more systematic review than the evidence based researches or surveyed study. There is need of exploring the effectiveness of technology-based approaches in mitigating medication errors. It is also recommended to explore more technology based approaches within the healthcare setting to minimize the medication errors.

What this article is adding in existing literature?

This article is adding to existing as it identified the different technology-based approaches in mitigating medication error and other literature support the individual study as well as literature review based on medication error, its barriers and knowledge.

What its impact and contribution to Saudi context?

This literature review has positive impact for making policies and training session to reduce the medication errors. This literature review contributes an important part in Saudi healthcare setting to develop the technology which mitigating the medication errors and provide the error free treatment to the patients.

### **Conclusion**

It is concluded that electronic bar codes on medication labels and packaging can improve patient safety by encoding a patient's medical record number (MAR) into a hospital's information system. This prevents medication errors and can be managed by using the STAMP technique and a checklist. Blockchain technology offers a safe, transparent, and unchangeable way to track drug transportation, potentially transforming drug supply chains and improving telehealth and telemedicine services. However, barriers to reporting medication administration errors among nurses include organizational and professional issues. However, the therapeutic range, which includes beneficial but not hazardous medication levels, is crucial for safe practice. Also problem-based learning methodology enhances social, communication, problem-solving, and self-learning skills, but requires more human resources and continuous training. Therefore, simulation programs for

nursing and other paramedical staff can improve medicine administration abilities and bridge theory and practice gaps.

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