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Assessing the Effectiveness of New Health Technologies in Promoting Medication Safety and Compliance in Daily Nursing Care; Findings based on Systematic Review

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ABSTRACT

Background: Digital Health Technologies DHTs are mobile health tools, AI, and wearable devices that have now become prominent tools that are actively transforming the health systems across the world. However, multiple barriers, such as technological systems, privacy, and compliance issues, and inconsistent utilization of technologies still exist.

Aim: The purpose of this study is to understand when, how, and why digital health technologies are used in healthcare organizations; what problems and benefits are encountered when implementing and using these technologies; and how the effectiveness of healthcare simulation in improving nursing competencies can be improved as a result of the use of such technologies.

Method: An analysis of published academic writing was completed involving 10 articles and studies published between the years 2020 and 2022. These studies encompassed empirical and conceptual research on technology development in health care, eHealth methods, mHealth approaches, artificial intelligence in the provision of care, and healthcare simulation.

Results: This review concluded that DHTs such as, mobile apps, SMS reminders, AI tools and simulation programs promoted patient safety, improved the medication compliance and supported the competence of the nursing students in medication safety. However, for these technologies to be integrated it became apparent that there are issues to do with technology design, organizational support and user access

that need to be addressed. The articles provided observable benefits of DHTs and issues that include privacy and accessibility, especially for locations with little or no access to technology.

Conclusion: Technology solutions for health have the potential for delivering a great deal of benefits to both patients and healthcare systems. But for these technologies to fit in the healthcare systems higher research is required that is able to solve infrastructure restrictions, improve data protection and make these technologies reachable for everybody. Furthermore, and particularly if policy makers and managers continue to innovate and apply boosted strategies, DHTs could significantly refigure the prognosis and paradigm of healthcare providers.

KEYWORDS: Digital Health Technologies, Medication Adherence, Mobile Health, Healthcare Simulation, Patient Safety, EHealth Interventions, Artificial Intelligence, Nursing Competencies.

1. Introduction

Medication safe and concordance are important aspects of high-quality health care especially within nursing practices; where a distinction of medication administration is regular and mandatory (Huter et al., 2020). These mistakes will result in complications some of which can be life threatening and will prolong the patient's stay in the hospital in addition to increasing the overall costs of health care. Therefore, the healthcare Industry has sought for advanced technological systems to improve accuracy, safety, and efficiency of the medicinal processes (Ridho et al., 2022). New technologies in health care are being adopted in clinical areas to help nurses and other health assistants in reducing on mistakes that may be involved in giving out drugs to patients as well as to boost patients' compliance. What this integration of technology aims at is to solve various issues that have for instance, been experienced in the administration of medications; enhance patients' results; as well as ease the work load faced by the healthcare facilities (Gates et al., 2021).

Information technologies such as Electronic Medication Administration Record eMAR, Bar Code Medication Administration BCMA systems, smart pumps and mobile health (mHealth) applications have emerged promising to revolutionize current medication practices. They should help nursing staff to dispense medication efficaciously; check dosages; and ensure they deliver the correct prescribed doses (Mbunge et al., 2021). With help of real-time data and alerts, those tools and applications can provide the link between complicated medication processes and safe environments for patient (Stephenson et al., 2020). Healthcare practitioners are more productive with such innovation since, for instance, nurses are on the cohort of practitioners that can be helped by such, reduction of human error and enhancement of medication protocols adherence (Kuwabara et al., 2021).

Both Barcoded Medication Administration BMA with medRite and electronic health records have made big improvements on documenting and verifying on medications administered. BCMA systems allow nurses to scan patient barcodes (Wong et al., 2020). That automatically checks the "five rights" of medication administration: the

right patient, the right medication, the right dose, the right route (Manyazewal et al., 2021). The right time eMAR helps implement this since it records all aspects of medication administration in real-time and essentially helps minimize the use of study records as well as enhance communication among the health care team (Fleming et al., 2020). These systems do not only improve the efficacy of ways of delivering medication but also help to reduce working time of a nurse more time to spend directly with a patient (Kitsiou et al., 2021).

Pump technology, especially when coupled with dose error reduction systems (DERS) is another innovation in the development for increasing medication safety in nursing care (Stoumpos et al., 2023). These infusion devices enable nurses to give intravenous I.V medications with more precision enabling reduced cases of over dosage or wrong I.V delivery rates (Hasegawa et al., 2020). Smart pumps can be set by the nurse to have codes with specific dose range, which can give an alarm when such errors are likely to occur (Babel et al., 2021). It is of such real-time feedback that aids nursing practice by lessening on the mental demand on the several people in health and helps in creating a safer environment within medication administration (Slevin et al., 2020).

Electronic medication management and monitoring enhancer continue to support medication adherence (Charlton, 2020). mHealth apps permit both nurses and patients to check the medication schedule, alert when a patient misses a dose, and track adherence data in the outpatient care setting. It makes these tools very helpful for the patients who have chronic diseases and those who take many medications at once (Kris-Etherton et al., 2021). Through using data from the digital adherence devices, the nurses can be in a position to observe non-adherence among the patients and take the necessary action this makes it easy to develop individualized care thus making it easier to deliver individualized patient care (Najafi et al., 2020).

Health technology is also instrumental when it comes to information sharing with patients regarding the medications to be taken and self-administration (Hogervorst et al., 2022). Mobile applications and other forms of - afterwards, where the nurse disseminates necessary medication-related information, and facilitates patients' understanding of the necessity to adhere to these. In this sense, patients will be able to acquire the appropriate amounts of medicine and learn about adverse effects of a certain medicine as well as the importance of specific medications (Torous et al., 2021). In the management of certain diseases through the educational instruments that are incorporated in these technologies. This improves the nurse patient relationship and avails patient roles to assume active roles under the instructions of the nurse (Kringle et al., 2020).

There are, nevertheless, several attendant difficulties inherent in the integration of these newfound technologies in nursing practice (Alemede et al., 2024). Many are the instances where technology integration to daily tasks may lead to technology-related errors hence the need to train the nursing staff before they can use technology products in their working practice (Marsch et al., 2020). New tools have to be learned and incorporated into practice, and the pressure is on from the time healthcare professionals get their handles on a new system to minimize errors resulting from lack of proper training or comprehension of the system (Sua et al.,

2020). In addition, data confidentiality and security are still important issues due to the proliferation of online health care sites and mobile applications that deals with the identification data of patients (Baryakova et al., 2023). It is important to require following the privacy standards in order for patient's data to be secure and people to trust in digital health solutions (Gates et al., 2021).

Hence, apart from technology and training, resource utilization as well as costs remain paramount in the implementation of these change solutions (Stoumpos et al., 2023). Few organizations or hospitals can afford the high price tag and this remains one of the major challenges in financing the technology like smart pumps, BCMA and so on for use in care delivery (Alemede et al., 2024). Leadership needs to consider whether or not these technologies are cost effective and analyze factors that include decrease in the probability of medication errors and increase in patient compliance as advantages as opposed to the costs (Stoumpos et al., 2023). Consequently, the demonstration of appropriateness of these technologies in use and how they reflect on clinical practice and patient outcomes should be done periodically.

It can be said that the evaluation of the efficacy of the new health technologies with regard to medication compatibility in nursing and patients' safety is crucial for improving the quality of the patients' treatment (Gates et al., 2021). The effectiveness of these technologies suggests that medication management could be revolutionized while effectively reducing the risk of mistakes and increasing patient compliance that are essential for safe patient and rational, efficient healthcare delivery in any setting (Sua et al., 2020). An overall assessment of the findings can be very helpful for several reasons to enhance the effectiveness of technology implementation in daily nursing practice, and for supporting safer care delivery structures (Alemede et al., 2024).

Problem Statement:

Unfortunately, despite recent advances in medical technology and the availability of newer drugs many adverse effects continue to plague the delivery of nursing care (Sua et al., 2020). Medication errors and non-adherence to treatment regimens are true risks to patient safety and serve to raise global health care costs substantially. Medication administration by nurses that is an imperative responsibility is challenging due to high stress levels and work volumes and high complexity of medications, plus the effects of human error. Interventions such as Electronic Medication Administration Record (eMAR), Barcode Medication Administration (BCMA) systems and smart pumps have being implemented to hopefully improve medication safety; however, research evidence on the impact of the innovation in actual practice is rather scarce. The present study aims to fill this gap by assessing the consequences of these technologies for medication safety and compliance in order to identify how these technologies may assist in minimizing the occurrence of medication errors and assist the nurses with caring for patients.

Significance of Study

Study work is valuable as it offers evidence about the role of health technologies, protecting medication safety and adherence in the nursing care, which is one of the

key areas of patient safety. The results of this examination of eMAR, BCMA, and smart pump use could help healthcare institutions identify efficiencies and productive uses of these technologies in nurses' work. Knowledge of how these technologies perform serves a purpose of properly allocating resources, educating nursing staff and in effect, decreases the number of medication errors leading to the betterment of patient care. The results of this study can be useful for the management and development of health care services, particularly for preparing decision makers' management decision-making process, and for nursing workers will be useful when searching for effective technological support in solving problems related to medication safety in practice.

Aim of the Study

The aim of this research is to evaluate of new technologies for health with regard to medication safety and adherence during nursing care. Namely, the study aims to assess the effectiveness of tools like Electronic medicine administration record (eMAR), Barcode Medication Administration (BCMA), and smart pumps with regards to the means, by which medication is administered with an aspect of precision, and the extent to which patients' prescribed regimens are followed, as well as, general safety of patients receiving the medicine. Such outcomes should help the study offer best practice suggestions on how to apply such technologies in boosting other practices in the nursing discipline and healthcare at large.

2. Methodology

This study in order to measure the outcomes of new health technologies on medication safety ad compliance in ordinary nursing practice. This study employed systematic literature review data to solicit information from nurses practicing from locations where eMAR, BCMA, and smart pumps were used. Qualitative data for technologies were based on medication safety outcomes, for instance, medication errors, compliance with medication administration protocols and general quality of nursing care.

Research Question

Research Question		New Health technologies such as electronic medication administration record (eMAR) bar code medication administration (BCMA) and smart pumps among other technologies are useful in delivering medication safety and compliance in the day to day nursing practice.
Population	P	Nurses working in hospitals and healthcare organizations that have implemented new health technologies, eMAR, BCMA, smart pumps for the administration of medicine.\
Intervention	I	Electronic medication administration records (eMAR), barcode medication administration (BCMA) systems and using smart infusion pumps in the administration of medications.
Comparison	C	Application of medication safety and compliance scores to determine the difference before the integration of the health technologies into practice environments.
Outcome	O	Reduction in the rate of adverse medication events causing patient harm and

		increased compliance with medication taken.
Timeframe	T	Data will be extracted and analyzed provided by the selected companies in the last 5 years which includes 2020- 2024.

Selection Criteria

Inclusion Criteria

1. Staff RNs with at least one year of experience in utilizing eMAR, BCMA and smart pump systems.

2. Others, who have adopted eMAR, BCMA and smart pump in their clinical facility medication administering plans,

3. Nurses who directly administer one or many drugs to patients.

Exclusion Criteria

1. The subgroup of inexperienced nurses in the application of the new health technologies.

2. Organizations and specifically healthcare facilities that has not adopted these technologies.

3. Nurses that work in administrative roles or who do not dispense medications.

Database Selection

The study will enlist articles from prospective databases including PubMed, CINAHL and Scopus, as these findings contain articles from peer-reviewed literature, clinical reports of medication safety and effectiveness of health technologies. These databases were selected because they contain a vast of health technology research articles and play a key role in sourcing for evidence based quality research papers.

Data Extracted

The data to be gathered for this study will comprise of; which health technologies are used (eMAR, BCMA, smart pumps), outcome data relating to medication safety (error rate, ADEs rate, missed doses); and the level of compliance data with medication regimens (patient adherence rate, adherence to protocols as practiced by the nurses). Further, quantitative records from nursing staff (years of experience, training received on these technologies) will also be incorporated to determine factors affecting the efficacy of these technologies. The data will also capture various aspects of implementation including adoption and usage by clinical settings for the past five years hence enabling comparison of results before and after technology implementation.

Syrex

Primary Syntax

("electronic medication administration records" OR "eMAR" OR "barcode

medication administration" OR "BCMA" OR "smart pumps")

AND

("medication safety" OR "medication errors" OR "adherence" OR "compliance")

AND

("nursing care" OR "nurses")

AND

("healthcare technology" OR "health informatics").

Secondary Syntax

("nursing practice" OR "patient safety")

AND

("clinical outcomes" OR "medication-related errors")

AND

("healthcare facilities" OR "hospital settings")

AND

("technology adoption").

Literature Search

Both PubMed and Scopus databases will be explored along with CINAHL, using a search range from 2020-2024, to identify a range of relevant articles. The search method will include both the primary and the secondary search for the articles related to the usage of health technologies in the process of nursing practice, mainly, involving eMAR, BCMA and smart pumps. These sources will involve published articles that are blend of research articles, clinical trials and systematic reviews that consider evidence on the potential of these technologies enhance medication safety and enhance medication compliance in nursing settings. The focus of the search is to find studies that describe the effects of these technologies in naturalistic practice and consolidate outcomes relevant to the study goals.

Table 2: Databases Selection

No	Database	Syntax	Year	No of Researches
1	PubMed	Syntax 1 (Primary) and 2 (Secondary)	2020 – 2024	175
2	Scopus			95
3	CINAHL			102
4	Cochrane			88

Table 2 below shows the databases we used in selecting the literature reviewed with specifics of the search syntax and number of retrieved articles in each database. Evidently, the primary and secondary syntax: eMAR, BCMA, smart pump, medication safety, care nursing practice, patient safety, and healthcare technology

were adopted to search each databases. The number of studies found from different sources is summarized from the year 2020 to 2024. As it is shown in figure two, PubMed provided the greatest number of studies, 175 articles Then, CINAHL gave 102 followed by Scopus which offered 95 articles while Cochrane offered 88 articles. This selection guarantees a cross-sectional sampling of the most recent literature and addresses diverse aspects of studies concerning the impact of health technologies on safety and medication adherence in the nursing field.

Selection of Studies

Study selection will be done based on the; title and abstract of research articles, since the study objectives are to assess health technologies in relation to nursing care, with respect to safety and compliance in medication. Only articles published between 2020 and 2024 will be utilised to guarantee that the investigations will explore the most innovative approaches to technology as well as nursing. Studies included in this review will be evaluated for quality based on the following criteria: focus on nursing care, use of health technologies such as electronic medication administration record (eMAR), barcode-assisted medication administration (BCMA), and smart pumps), and reporting of outcomes like medication safety, error rate, and compliance. Any studies which do not fulfill the above mentioned criteria, or which were conducted prior to the specified year, will not be included.

This review process were be demonstrated by a PRISMA flowchart showing the steps in selecting the articles beginning with the search for articles in the databases. After that, the studies were further screened by endoscopic titles and abstracts and compared with the identified inclusion and exclusion criteria. Potential studies were reviewed, compared and prosed, and then, specific criterion and inclusion criteria will be used to make the final identification of the studies to be included in the review. The flowchart will enable the documentation of the total number of studies that were identified, screened, reviewed for eligibility, and included in the final synthesis, to show the reader of this manuscript, the systematic approach used in the conduct of the literature review.

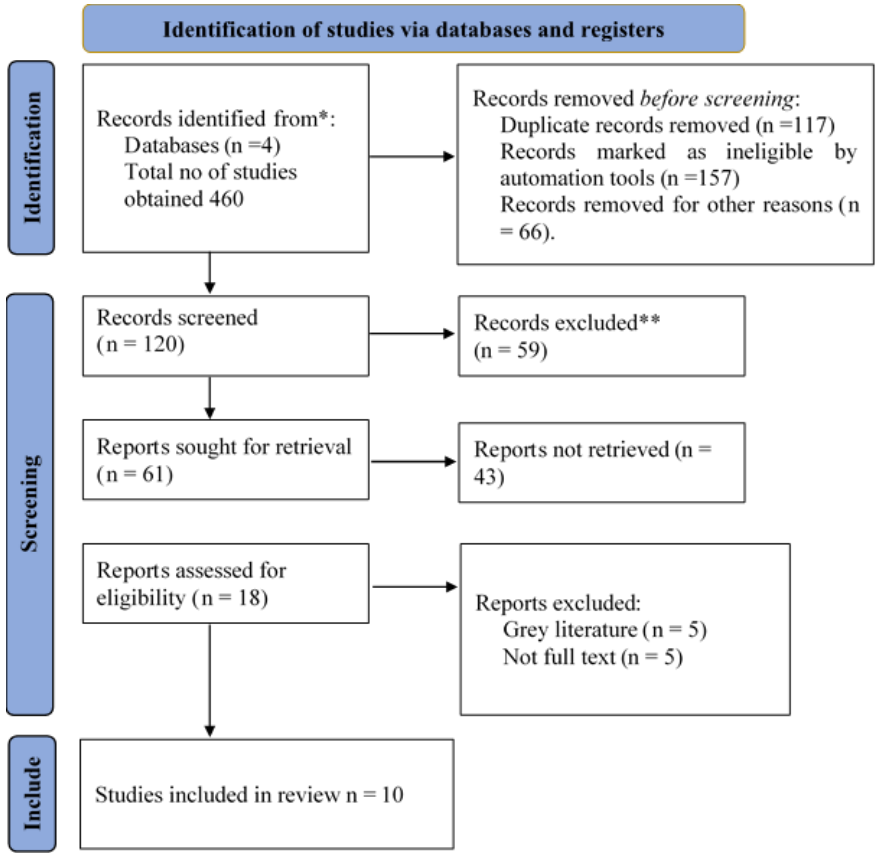

Figure 1 PRISMA Flowchart (1 paragraph)

The PRISMA 2020 flow diagram presents the work done in the systematic review to identify and select studies for use in the study. Based on an electronic search of four databases and registers 460 records were retrieved. Before screening, 117 of the records were duplicate, 157 records were automatically flagged ineligible, and 66 other records excluded. Out of 120 records that met the initial search questions, 59 were screened out from the study. Till the end of the study a total of 61 reports were looked for, however 43 reports are not found. Subsequently, 18 reports were evaluated for their suitability for inclusion and 5 reports were deemed to be inapplicable, 5 of which were grey literature, and 5 that were not in full text form. Finally, ten reports were selected for inclusion in the present review.

Quality Assessment of Studies

In order to ensure methodological rigour and accuracy of articles included in this systematic review, the quality of articles included in this systematic review were assessed using a quality assessment tool designed for this purpose. The systematic assessment of salient factors like study methodology, sample size, data collection and analysis approaches were done, during this process. Reporting of findings were

done in a very transparent manner; specific focus will be directed to the criteria used for selecting the study participants and those that were excluded; reliability of measuring outcomes will be pursued. Literature reviews were evaluated according to their quality in reducing bias and enhancing validity; thus, papers of high validity will prevail in the course of synthesis. In order to reduce biases that may be occasioned by funding or researcher affiliation among others, such sources of bias will also be taken into account to the extent that they will influence the conclusions arrived at from the studies under review.

Table 3: *Assessment of the literature quality matrix*

#	Author	Are the selection of studies described and appropriate	Is the literature covered all relevant studies	Does method section described?	Was findings clearly described?	Quality rating
1	Vaismoradi et al	YES	Yes	Yes	Yes	Good
2	Awad et al	Yes	No	Yes	Yes	Fair
3	Craig et al	Yes	Yes	Yes	Yes	Good
4	Pouls et al	Yes	Yes	Yes	Yes	Good
5	Whitelaw et al	Yes	Yes	Yes	Yes	Good
6	Mosnaim et al	Yes	Yes	Yes	Yes	Good
7	Schorr et al	Yes	Yes	Yes	No	Fair
8	Alami et al	NO	Yes	Yes	Yes	Good
9	Mbunge et al	Yes	Yes	Yes	Yes	Good
10	Solomon & Rudin	Yes	Yes	Yes	Yes	Good

The quality of the literature reviewed in the systematic study is shown in Table 3 below. Each study is evaluated based on four criteria: The criteria that were used include the relevance and accuracy in selection of the studies, ample coverage of the pertinent literature, description of techniques and the clarity of the conclusions. All in all, latter eight studies reveal most of the high quality attributes Though, Vaismoradi, Craig, Pouls, and Whitelaw et al are specifically identified as ‘Good’ in criteria 1-5 out of them. Other criteria which reduced their rating to “Fair” are, incomplete literature review as noted by Awad et al as well as the unclear findings as noted by Schorr et al.. The study by Alami et al. was put into a “Good” basket although the authors did not give a detailed description of the samples’ selection. In general, the current systematic review is based on acceptable quality of the majority of the identified studies, which is an advantage.

Data Synthesis

Synthesizing data in this systematic review entails both merging and contrasting the results of the included studies to make broader conclusions on the efficacy of new health technologies towards medication safety and adherence within nursing care. The synthesis will concentrate on the subject of differences, similarities and trends of

the outcomes and put particular emphasis on the effects that the technologies like eMAR, BCMA, and smart pumps have on rates of medication errors, medication adherence, and nursing practices. The studies' qualitative results will be combined with the quantitative data when possible using a narrative synthesis if it is a qualitative study or meta-analysis if it is a quantitative study to express the effect of these health technologies. This approach also guarantees the utilization of the best technologies to enhance medication safety and compliance in clinical practice while gaining insights into the impact and applicability of different technologies from the evidence.

Table 4: Research Matrix

Author, Year	Aim	Research Design	Type of Studies Included	Data Collection Tool	Result	Conclusion	Study Supports Present Study
Vaismoradi et al., 2020	To synthesize knowledge and explore factors that influence nurses' adherence to patient-safety principles.	Systematic Review	Empirical studies focusing on patient-safety adherence	Theoretical domains of Vincent's framework	Six articles on adherence to safety principles across various clinical nursing interventions were reviewed.	Revealed individual and systemic factors influencing nurses' adherence to patient safety principles. More studies are needed for better knowledge of measures to improve adherence and patient-safety outcomes.	Yes
Awad et al., 2021	To review digital health technologies improving patient care in healthcare 4.0.	Literature Review	Studies on healthcare technologies such as sensors, 3D printers, robots, and IoT	Review of healthcare technologies	Identified technologies such as sensors, 3D printers, and IoT that enhance patient care in healthcare settings.	Digital health technologies are transforming healthcare, with significant potential for improving patient care at various stages of	Yes

						the patient care pathway.	
Craig et al., 2021	To examine the effects of MSE simulation programs on nursing student knowledge and competency in safe medication administration.	Quasi-Experimental Study	Nursing student clinical simulations focused on medication safety	Medication Safety Knowledge Assessment (MSKA)	The intervention group performed significantly better in subsequent simulations.	High fidelity simulation is an effective teaching strategy for medication safety practices in nursing education.	Yes
Pouls et al., 2021	To evaluate the effectiveness of interactive eHealth interventions on medication adherence in adults using long-term medication.	Systematic Review	Randomized controlled trials on eHealth interventions for medication adherence	Cochrane Risk of Bias tool	Most interventions using mobile phone apps and SMS showed positive effects on medication adherence.	eHealth interventions, especially those improving patient engagement and medication management skills, are effective for enhancing medication adherence.	Yes
Whitelaw et al., 2021	To identify barriers and facilitators of digital health technology uptake in cardiovascular care.	Systematic Scoping Review	Studies on barriers and facilitators in adopting DHT in cardiovascular settings	Qualitative and Quantitative Methods	Identified factors like internet access, user-friendliness, organizational support, and workflow efficiency as crucial for DHT uptake.	Organizational support, internet access, and user-friendly technologies are essential for the adoption of DHT in cardiovascular care.	Yes
Mosnaim, G., Safioti, G., Brown, R., DePietro, M.,	To identify barriers and facilitators to digital health technology (DHT)	Systematic Review	Qualitative, Quantitative, and Mixed-Methods Studies	Thematic Analysis	Identified factors influencing DHT uptake: patient-level barriers	Factors like internet access, technology user-friendliness,	Yes

Szefler, S. J., Lang, D. M., ... & Merchant, R. K. (2021).	uptake in cardiovascular care.				(e.g., technology difficulty, internet issues), clinician-level barriers (e.g., increased workload). Facilitators included improved communication and personalized tech for patients.	organizational support, and data integration are crucial in DHT adoption.	
Schorr, E. N., Gepner, A. D., Dolansky, M. A., Forman, D. E., Park, L. G., Petersen, K. S., ... & Wenger, N. K. (2021).	To examine the impact of mobile health (mHealth) technology in secondary cardiovascular disease prevention for older adults.	Systematic Review	26 studies focused on mHealth for secondary CVD prevention, particularly lifestyle change and medication adherence.	Review of Literature	Improvements in health behaviors and medication adherence, particularly with SMS components. Barriers identified: affordability, usability, privacy, and security.	mHealth can be effective in secondary prevention, but barriers such as usability, privacy, and cost need to be addressed for older adults.	Yes
Alami, H., Lehoux, P., Auclair, Y., de Guise, M., Gagnon, M. P., Shaw, J., ... & Fortin, J. P. (2020).	To explore the implications of artificial intelligence (AI) in health technology assessment and its integration into healthcare systems.	Conceptual Analysis	AI-based health technology assessments	Literature Review, Stakeholder Analysis	AI has the potential to transform healthcare systems by improving quality and efficiency but also introduces significant risks. Stakeholders' perspectives are essential for its responsible integration.	AI's use in healthcare requires a holistic, systemic evaluation beyond just technical performance to address potential risks and maximize benefits.	Yes
Mbunge, E., Batani,	To assess the use of digital	Systematic Review	Studies on digital health	Systematic Review	Digital health technologie	There is a need for increased	Yes

J., Gaobotse, G., & Muchemwa, B. (2022).	health technologies in South Africa during the COVID-19 pandemic and their associated challenges.		technologies in South Africa during the pandemic.	of Literature	s like SMS-based solutions, mobile apps, telemedicine, and AI were adopted, but challenges included infrastructural, financial, policy, and cultural barriers.	rural community networks, policy adjustments, and sustainable strategies to address barriers in digital health technology use.	
Solomon, D. H., & Rudin, R. S. (2020).	To evaluate the opportunities and challenges of digital health technologies in rheumatology.	Literature Review and Discussion	Studies on the use of digital health technologies in rheumatology, including wearable tech and AI.	Literature Review	Digital health technologies have shown potential in improving rheumatology care, but barriers like design, integration with patient outcomes, and technology accessibility need addressing for better adoption.	Engagement with end users and proper integration into clinical practice are key for the effective use of digital health technologies in rheumatology.	Yes

The literature reviewed in the present paper is useful to understand how digital health technologies (DHTs) can support the enhancement of different issues in healthcare settings and contribute to changing the practices. The role of the organizational support and the internet connectivity and the ease of use in cases where the DHTs were used in specialty care domains, including cardiovascular care, rheumatology, and medication management was underlined by several studies. Because of the following reasons; Cost, feasibility, and compatibility with clinical praxis, mobile health (mHealth), artificial intelligence (AI), and eHealth interventions are still a challenge. The observations support further research aiming at overcoming these obstacles and achieving stable and equal DHTs availability in any region. The current research is supported by these studies since they aim at the general applicability and utilization challenges of the dHI, in the contexts of enhancing the delivery of healthcare as well as patient safety.

3. Results

Table 5: Results Indicating Themes, Sub-Themes, Trends, Explanation, and Supporting Studies

Themes	Sub-Themes	Trends	Explanation	Supporting Studies
Patient Safety	Nurses' adherence to safety principles	Individual and systemic factors	Factors like nurse experience, leadership support, and organizational culture influence adherence to safety principles in clinical settings.	Vaismoradi et al., 2020
Digital Health Technologies	Adoption and impact on patient care	High adoption of digital tools	Digital technologies such as sensors, IoT, and AI enhance patient care by improving diagnostics, monitoring, and personalized treatment plans.	Awad et al., 2021; Mbunge et al., 2022
Medication Adherence	eHealth interventions and mobile apps	Positive outcomes in medication adherence	Mobile apps, SMS reminders, and eHealth platforms improve medication adherence by increasing patient engagement and management of their treatment.	Pouls et al., 2021; Schorr et al., 2021
Healthcare Simulation	Impact of simulations on student competencies	Effective in enhancing nursing skills	High fidelity simulations improve knowledge and competency in areas like medication safety, preparing students for real-world clinical situations.	Craig et al., 2021
Technology Integration	Barriers and facilitators of DHT uptake	Technology barriers need addressing	Organizational support, user-friendliness, and integration with existing workflows are critical for the successful adoption of DHTs in healthcare.	Whitelaw et al., 2021; Mosnaim et al., 2021
Mobile Health (mHealth)	Secondary cardiovascular disease prevention	Improvements in health behavior and medication adherence	mHealth tools like SMS interventions have improved lifestyle behaviors and adherence to cardiovascular medications, especially among older adults.	Schorr et al., 2021
Artificial Intelligence (AI)	Role of AI in healthcare assessments	Potential for transformation but with risks	AI enhances healthcare assessments by improving efficiency but introduces risks related to privacy, data integrity, and integration with clinical systems.	Alami et al., 2020
Digital Health in COVID-19	Use of digital tools during the pandemic	Surge in digital health tool adoption	The COVID-19 pandemic accelerated the adoption of digital tools, especially for remote	Mbunge et al., 2022

			consultations, telemedicine, and patient monitoring.	
Technology in Rheumatology	Wearable tech and AI integration in rheumatology	Increasing use but with integration challenges	Digital health technologies like wearables and AI offer potential for improving rheumatology care but face challenges in design and integration.	Solomon & Rudin, 2020
AI in Healthcare Systems	Systemic integration of AI	Risk and opportunity balance	AI has the potential to transform healthcare systems, but its integration requires careful stakeholder input to manage risks while maximizing benefits.	Alami et al., 2020

From the selected studies, principal findings enunciate ever-evolving applicability of DHT in various health care settings, distinction of both opportunities and afflictions. Patricia W. O'Donnell and Susan E. Case found that experience, leadership support, and culture were all fundamental silos that determined whether nurses safely adhered to principles or not. The use of digital health such as sensors, IoT, AI, and mobile applications was associated with improved patient care and medication compliance and for supporting behaviour changes as well as chronic disease control and secondary prevention of cardiovascular diseases. Health care simulation, especially the high fidelity ones were found effective in enhancing nursing competencies especially on issues of medication. However, there are challenges affecting adoption of the technologies, including issues to do with technology compatibility, ease of use, and organizational support. Moreover, there is a massive possibility on how AI can revolutionize healthcare systems globally, but its incorporation need great scrutiny in order to avoid the threats it has that might compromise privacy and accuracy of data. COVID-19 has put an emphasis on integrated digital technologies and remote care and telemedicine in particular. In combination, these results suggest that there is much to be gained from the effective design and implementation of digital health technologies but also that challenges remain that require ongoing research and developmental effort to overcome.

4. Discussion

There is also an agreement that the use of digital health technologies (DHTs) in healthcare systems is still a novel solution considered as one of the major disruptors, which affect patients and their health. DHTs have particularly been used in one main area that is patient safety, with particular reference to the extent that the nurses adhere to safety standards. Internal organizational features like; experienced nurse, organizational cultures, and leadership support were highlighted to influence practicing of established patient safety standards. Vaismoradi et al. (2020), focused on individual- and system-level factors with the suggestion that more experimental research is required to elucidate possible ways to enhance the safety performance of clinical workplace environments. These chimes with arguments of other authors who

have pointed out that culture and leadership of an organization are influential in determining compliance to safety requirements (Awad et al., 2021).

The applications of the sensors, IoT devices and AI in the digital health setting have been evidenced to improve the quality of patient care at different developmental phases of care. Not only does it escalate the standard of diagnosing patient conditions but also different treatment options for specific patients augmenting overall quality and effectiveness of the patient care. Awad et al. (2021) pointed out that the increased implementation of DHTs has transformed healthcare industry especially regarding the care of chronic diseases. In the same manner, Mbunge et al. (2022) found out that the increased use of the digital tools occurred during the COVID-19 pandemic whereby, utilizes tele-consulting, telemedicine, mHealth apps, and artificial intelligence in the continuity of care even when face-to-face encounters were challenging. However, these technologies pose challenges to the integration into a healthcare facility besides infrastructural and financial structures (Whitelaw et al., 2021; Mosnaim et al., 2021).

Of all the functions, one that has received a clear endorsement by DHTs is on medication compliance. Research also indicates that m-Health, SMS and other forms of eHealth increase medication compliance among patients taking chronic medicines. In a systematic review and meta-analysis of Pouls et al. (2021) when using eHealth interventions, positive effects on medication adherence were evidenced, especially through mobile phone apps and SMS reminders. This was further supported by Schorr et al., (2021), which found that use of mHealth tools improved health behaviours and medication management especially in the SCVP population. It has been established that digital reminders have proved helpful since they eliminate all barriers regarding compliance, including forgetfulness and lack of motivation, particularly among aging patients, who are most likely to fail to adhere to their prescriptions (Schorr et al., 2021).

However, as can be seen from the above presentation, DHTs are endowed with remarkable prospects, and yet a number of impediments have to be overcome to enable the broader harnessing and integration of DHTs into the healthcare framework. Among the most common challenges shown in several papers, the problem of technology implementation into the current healthcare processes is acknowledged. According to Whitelaw et al. (2021) and Mosnaim et al. (2021), implementation of DHTs depends on organizational support and user friendliness and compatibility with the existing or previous system. By arguing that effective digital health interventions require both technological advancement and the implementation that follows their adoption in actual healthcare settings, this conclusion reinforces the centrality of health-care organizations to the design, testing and deployment of effectively functioning digital health interventions. This means the enhancement of human resource development of health professionals and of infrastructure development, as well the provision of all the necessary technical support.

Similarly precise simulation replication has also been established as a relevant approach in enhancing the overall competencies of nurses especially in safety of medications. High-fidelity simulations have been defined by Craig et al. (2021) to

enhance the performance of the nursing students in subsequent assessment of medication safety knowledge. Such simulations mean that learners can participate in practice clinical situations that develop their clinical judgement and practical skills in safe care delivery. With the changes in nursing education, it has become imperative that simulation programs designed to mimic practice settings be incorporated into the education process to prepare the next generation of nurses to manage difficult patient care responsibilities appropriately. This fact is also confirmed by research that focuses on the effects which simulation-based education has on the increase of the knowledge and competency of the healthcare workers.

This paper aims to look into potential of AI in healthcare assessment and accurate diagnosis to find that it has the capacity to revolutionize healthcare practices. Alami et al. (2020) observed that although the application of AI offers the prospect of gain greater efficiency in the healthcare organizations, these systems' incorporation remain an issue of distinct ethical advisements concerning confidentiality and security. Even though the integration of AI in healthcare assessments is possible, the use of AI also poses some risks which if not handled properly can slow down or hinder its implementation on health care assessments, it therefore calls for a systemic approach on how to contain the risks that may arise while enjoying the benefits of AI. In this regard, Solomon and Rudin (2020) covered the area of AI and wearable technologies in rheumatology and concluded that, despite a great deal of potential for these technologies in rheumatology, challenges in design and implementation of the technologies exist. Thus the future healthcare AI approaches should be able to overcome these integration challenges in delivering tangible improvement in patient care.

Finally, digital health technologies provide enormous opportunities to enhance the conditions of patients and healthcare, medication compliance, and knowledge of the professional staff. However, those technologies can reap benefits if effectively adopted but they face numerous challenges that are infrastructural, organizational and user acceptance. Reviewing the literature of the studies leads to conclusion that digital health tools could significantly improve healthcare, yet a comprehensive approach to adoption, staff education, and barriers' management should be implemented.

Future Direction

The future line of the research and development for DHTs is concerned with the facilitation of integration of DHTs into the healthcare systems of the various countries with regard to infrastructure, usability as well as the professional development programs for the various healthcare stakeholders. More studies are required to know the benefits of DHT in chronic disease treatment and management, and mental health over the long term.. Further, more enhanced artificial intelligence instruments, wearable technologies as well as mobile health platforms for distinct consumer requirements also has great potential. Subsequent research should also address barriers to privacy and guarantee that such technologies are available to all communities regardless of national origin and age to result in justice in the provision of care.

Limitations

A major weakness of this line of literature is that most of the studies conducted have been cross-sectional meaning that there is limited understanding of the efficacy of digital health technologies in the long run. Most are cross sectional to give data in the short term, and as such are not capable of continually measuring the cumulative effects of DHTs on patients' safety, adherence to medications and overall health status. Also, the advancing state of technology implies that the technological environment in various healthcare centres will differ implying that results obtained in one region or health sector may be different from those in others. Finally, the problem of data privacy and security is still a major concern for which there is little investigation explored in most of the surveyed research on digital health.

5. Conclusion

Therefore, digital health technologies have revealed their possibilities to revolutionize patient's care, advance medication compliance, and increase competencies of healthcare employees. However, while the adoption of the technologies is well supported in many fields, considerable challenges need to be addressed regarding infrastructure, organization, and ethic in healthcare systems. However, there are several recommendations of the use of AI wearables mobile health tools, it is important to use them with caution to avoid issues like violation of data privacy. Therefore, more concerted efforts and research and development investments are required in the future in order to harness even the true potential of digital health for patients as well as overcoming above challenges to enhance the quality of health care.

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