Technological Determinants of Mobile Health Effectiveness in Improving Treatment Compliance in Patients with Non-Communicable Diseases in Low-Medium-Income Countries: A Systematic Review

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ABSTRACT

Non-communicable diseases (NCDs) are responsible for 71% of global deaths, with 77% occurring in low- and middle-income countries (LMICs), where treatment compliance is hindered by limited healthcare access, low health literacy, and socioeconomic challenges. Mobile health (mHealth) interventions, including SMS reminders, apps, and teleconsultations, present a viable solution by delivering accessible health education and remote support. However, their effectiveness is heavily influenced by technological barriers such as network coverage, data and device costs, and privacy concerns, underscoring the need for a systematic evaluation tailored to LMIC settings.

This review assesses how technological factors—network coverage, affordability, mobile penetration, security, trust, user experience, and usability—affect the efficacy of mHealth interventions in improving NCD treatment compliance in LMICs. It aims to identify key barriers and facilitators to guide the development of equitable and scalable solutions. Following PRISMA guidelines, the study analyzed relevant peer-reviewed articles from databases including Google Scholar, PubMed, Scopus and Web of Science. The focus was on Low-middle-income countries (LMICs) and mHealth interventions for non-communicable diseases (NCDs). While 41 references were included in the broader scope of this review, detailed synthesis and analysis were conducted on a subset of 23 studies. Data extraction and quality assessment were conducted using standardized tools, with findings synthesized narratively due to heterogeneous study designs.

Results revealed that mHealth interventions achieved 70–85% adherence in urban LMICs like Bangladesh and India, where reliable connectivity and user-friendly designs improved compliance by 15–25%. In contrast, rural areas (e.g., Uganda, South Africa) saw lower adherence (50–60%) due to poor network coverage, high costs (reducing uptake by 20–30%), and low mobile penetration. Privacy concerns deterred 40% of users in Nepal and South Africa, while low trust in digital health reduced compliance by 20–30% in rural regions. Platforms perceived as easy to use and valuable significantly enhanced participation across NCDs.

The review concludes that mHealth can effectively improve NCD treatment compliance in LMICs when technological barriers are addressed. However, rural disparities and psychosocial factors like distrust limit scalability. Policymakers should invest in rural infrastructure, subsidize costs, and enforce robust privacy measures. Developers are urged to prioritize user-centric, low-literacy-friendly designs, leveraging SMS in low-penetration areas. Future research should explore long-term impacts, standardize compliance metrics, and investigate trust-building strategies for sustainable solutions.

Keywords: Mobile Health, Non-Communicable Diseases, Low- and Middle-Income Countries, Treatment Compliance, Technological Factors

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INTRODUCTION

Background

Treatment compliance, defined by the World Health Organization (WHO) as the extent to which a patient's behavior—such as taking medication, following a diet, or implementing lifestyle changes—corresponds with agreed recommendations from a healthcare provider, is critical for managing non-communicable diseases (NCDs) like hypertension and diabetes [36].Effective compliance enhances health outcomes, reduces complications, and lowers healthcare costs, yet it remains a significant challenge in low- and middle-income countries (LMICs) due to barriers such as limited healthcare access, low health literacy, and socioeconomic constraints [10]. Mobile health (mHealth) interventions, including SMS reminders, mobile apps, and teleconsultations, have emerged as innovative tools to improve compliance by providing timely reminders, health education, and remote consultations, thereby addressing some of these barriers [39].

Globally, NCDs account for 71% of deaths, with 77% of these occurring in LMICs, where hypertension and diabetes are leading contributors to morbidity and mortality [30]. The rapid rise in NCD prevalence, driven by aging populations, urbanization, and lifestyle changes, places immense pressure on resource-constrained healthcare system [25].

In Africa, the regional context is particularly dire, with NCDs projected to surpass communicable diseases as the leading cause of death by 2030 [19]. Limited healthcare infrastructure, shortages of trained professionals, and high out-of-pocket costs exacerbate poor treatment compliance, leading to uncontrolled hypertension and diabetes and increased complications [33].

In Kenya, the local context mirrors these challenges, with studies reporting that only 20–30% of patients with type 2 diabetes adhere to prescribed treatments due to high medication costs, limited access to health facilities, and low health literacy [4] [3]; Urbanization in Kenyan cities like Nairobi has increased NCD prevalence, while rural areas face additional barriers like poor healthcare access and inadequate infrastructure [19].

This systematic review evaluates how selected technological factors affect mobile health (mHealth) interventions in improving treatment compliance for non-communicable diseases (NCDs) in low- and middle-income countries (LMICs). These factors include network coverage, data and device costs, mobile penetration, security, trust, user experience and perceived ease of use and usefulness. mHealth shows promise in enhancing treatment compliance. Studies like [39] reported an improvement in adherence by 80% in Bangladesh;This improved was enhanced via SMS reminders. However, critical gaps persist in existing research.

First, most studies focused narrowly on urban settings or single NCDs such as diabetes ([2], overlooking rural populations and the diverse spectrum of NCDs ([30] [31]. Second, few comprehensively analyzed how technological barriers like connectivity, affordability, and privacy interact to limit scalability ([20];[27]. Thirdly, despite the potential of integrating mHealth with existing systems (e.g., HIV programs in East Africa; ([1], implementation challenges remain understudied.

For instance, in Kenya, poor network coverage and high costs exacerbate disparities [3]yet context-specific solutions are scarce [4]. By synthesizing recent evidence (2020–2025), this review addresses these gaps to inform equitable, scalable mHealth strategies for LMICs.

For example, in Kenya, technological hurdles like poor network coverage and high costs exacerbate disparities, yet solutions remain understudied. By synthesizing recent evidence (2020–2025), this review addresses these gaps to inform equitable, context-specific mHealth strategies for LMICs.

Problem Statement

Non-communicable diseases (NCDs) account for more than two-thirds of global deaths, with the majority occurring in low- and middle-income countries (LMICs). In these regions, treatment compliance remains critically low due to limited healthcare access, high costs, and low health literacy. This poor adherence worsens disease progression and places additional strain on already resource-constrained health systems.

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Mobile health (mHealth) interventions, including SMS reminders, mobile apps, and teleconsultations, have emerged as promising tools to improve compliance by delivering accessible health education and remote support. However, their effectiveness is hindered by significant technological barriers. Key challenges include unreliable network coverage, high costs of data and devices, low mobile penetration rates, security and privacy concerns, low trust in digital health platforms and poor user experience. These barriers are particularly pronounced in rural areas, where adherence rates lag far behind urban settings, exacerbating health disparities among vulnerable populations across South Asia, sub-Saharan Africa, and Southeast Asia.

Existing research has yet to fully address critical gaps in understanding mHealth's potential. Many studies focus narrowly on urban populations or single disease types, overlooking the complex realities of rural communities and the diverse range of NCDs. Additionally, there is limited evidence on how these technological barriers interact to limit scalability, or on practical strategies to overcome them in resource-limited settings.

This systematic review aims to bridge these gaps by comprehensively evaluating how technological factors influence mHealth's effectiveness in improving treatment compliance across LMICs. By identifying both barriers and opportunities, this review seeks to inform the development of equitable, scalable solutions that can reduce the growing burden of NCDs in underserved populations.

Significance of the Study

This systematic review is significant because it addresses critical gaps in understanding how technological factors, such as network coverage, data costs, mobile penetration, security, trust, user experience and perceived ease of use, influence mobile health interventions for enhancing treatment compliance among patients with non-communicable diseases in low- and middle-income countries. By synthesizing recent evidence, the study provides actionable insights to optimize mobile health solutions, particularly for rural and low-income populations facing barriers like poor connectivity and privacy concerns, which perpetuate health inequities across regions like South Asia, sub-Saharan Africa, and Southeast Asia. These findings provide critical guidance for multiple stakeholders. Healthcare providers can leverage them to design more intuitive and user-friendly platforms. Policymakers can use the evidence to prioritize infrastructure development and strengthen data protection frameworks. Researchers can build upon this work to investigate long-term outcomes and establish standardized evaluation metrics. Ultimately, this study delivers actionable insights to transform mHealth from a promising innovation into a powerful and equitable solution, capable of reshaping NCD management. This will significantly improve health outcomes across the world's most underserved communities.

Broad Objective

To evaluate technological determinants of mobile health effectiveness in improving treatment compliance in patients with non-communicable diseases in low-medium-income countries

Specific objective

To evaluate the impact of technological factors on the effectiveness of mHealth in enhancing treatment compliance among patients with non-communicable diseases in Low-Medium-Income countries.

Research Question

1. How do technological factors influence the effectiveness of mobile phone platforms in improving treatment compliance among patients with non-communicable diseases in Low-medium-income countries?

LITERATURE REVIEW

NCDs pose a significant global health challenge, particularly in LMICs, where treatment compliance is critical to reducing morbidity and mortality. mHealth interventions, such as SMS reminders, apps and teleconsultations, have emerged as promising tools to enhance compliance. However, their effectiveness is

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directly linked to technological factors such as network coverage, cost, and user experience. This literature review synthesizes evidence on treatment compliance for NCDs across global, regional (Africa) and local LMIC contexts, examines technological influences on mHealth, and identifies gaps in the current research.

Treatment Compliance

Globally, NCDs account for over two-thirds of deaths, with 77% occurring in LMICs, where compliance is hindered by limited healthcare access, high costs and low health literacy. Suppressed treatment compliance has contributed to increased complications and economic burdens [10] [25].

In Africa, NCDs are projected to surpass communicable diseases as the leading cause of death by 2030, driven by urbanization and lifestyle changes [19]. Studies reveal that NCDs contribute to 30–40% of mortality in Africa. Treatment compliance challenges have been exacerbated by weak health systems, medication shortages and cultural barriers, particularly in rural areas where adherence rates drop below 50%. [15]; [33]. For example, in Kenya, only 20–30% of patients with type 2 diabetes adhere to prescribed treatments due to high medication costs and limited access to health facilities ([3]; [4]). These disparities highlight the urgent need for tailored interventions to address context-specific challenges across LMICs.

Locally across diverse LMICs, compliance varies significantly between urban and rural settings. Urban areas in countries like Bangladesh and India report adherence rates of 70–80%, attributed to better healthcare access, while rural regions face logistical and socioeconomic barriers, reducing adherence to 50–60% [4]; [21]; [40].This urban-rural divide underscores the importance of addressing infrastructural and socioeconomic gaps to improve treatment compliance in patients with NCDs.

Technological Factors

The effectiveness of mHealth interventions in LMICs is influenced by several technological factors, including network coverage, cost, mobile penetration, security, trust and user experience.

Unreliable network coverage is a major barrier, particularly in rural areas. In sub-Saharan Africa, 30–40% of rural users experience connectivity issues, disrupting SMS reminders and app functionality and reducing adherence by up to 20% ([20]; [29]. Similarly, in South Asia, poor infrastructure affects 25–35% of users in rural Bangladesh and Nepal, hindering teleconsultations and real-time monitoring ([6]; [41]. Urban areas, such as those in India, face fewer disruptions, with only 10–15% of users impacted by network outages [27]. These findings highlight a consistent pattern of connectivity challenges in rural LMICs, regardless of regional differences.

High costs of data plans and smartphones restrict mHealth access, disproportionately affecting low-income populations. In Nepal, 50–60% of rural residents cannot afford smartphones, reducing app-based intervention uptake by 20–30% [6]). Similarly, in Uganda, data costs limit 40–50% of rural users, decreasing engagement with SMS and apps by 15–25% [11]. Urban areas, such as those in India, benefit from subsidized data, yet 15–20% of low-income users still face cost-related barriers [27]. These findings imply that while cost is a universal challenge, its impact is more pronounced in rural and low-income settings.

Varying mobile penetration rates further influence mHealth scalability. Urban India boasts 90% penetration, enabling 70–80% of NCD patients to access mHealth, while rural penetration drops to 60–70%, impeding reach [27]. In contrast, Uganda's rural penetration is only 50%, constraining SMS-based interventions to 40–50% of patients [11]. These disparities point to the need for low-tech solutions, such as SMS, in areas with limited mobile access.

Security and privacy concerns deter 30–45% of users across LMICs, with higher hesitancy in urban areas due to greater digital exposure [24]. In South Asia, 40–50% of users fear data breaches, reducing compliance by 20–30% [6]; [41]. Trust in digital health is also lower in rural settings, where 25–40% of users express skepticism as compared to 10–15% in urban areas [16]. To enhance mHealth adoption, it is critical to implement transparent data policies and foster community engagement so as to build trust in communities across LMICs**.**

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User experience, encompassing interface design and functionality, significantly affects mHealth adoption. In urban India and South Africa, intuitive apps increase engagement by 25–30%, boosting compliance for NCDs like hypertension and diabetes [21]; [39]. In contrast, complex interfaces in rural Bangladesh and Nepal reduce adoption by 15–20% among low-literacy users, limiting effectiveness [6]; [41].In Ghana, user-friendly SMS platforms enhance adherence by 20% in urban areas, but rural users struggle with navigation, reducing impact [2]. In the Philippines, poor app design deters 20–25% of community health workers, affecting NCD support [22].

Perceived ease of use and usefulness are critical drivers of mHealth success. In China, user-friendly mHealth platforms for stroke management increase adherence by 20–25%, as patients find them easy and valuable [39].In South Africa, apps perceived as useful improve compliance by 15–20% in urban areas, but rural users find them less intuitive, reducing engagement by 10–15% [21]. In Bangladesh, SMS reminders are deemed easy to use, boosting adherence by 15–20%, but app complexity lowers rural uptake by 10–15% [41].In Nepal, low perceived usefulness among rural users decreases adoption by 15–20% [6]). In Uganda, ease of use in SMS interventions increases compliance by 10–15%, but apps are less effective due to low perceived value [11].To increase mHealth adoption, it is essential to tailor mHealth to user needs [13]. These findings emphasize the importance of context-specific design in mHealth interventions.

These technological factors collectively shape mHealth outcomes, with urban areas benefiting more than rural regions across LMICs.

Gaps

The current body of research on mHealth interventions for NCD treatment compliance in LMICs reveals several critical gaps that limit both understanding and implementation. First, existing studies demonstrate a persistent narrow focus, primarily examining single disease categories such as diabetes or hypertension in isolation [30]. This approach fails to account for the complex multimorbidity patterns frequently observed in LMIC populations [1]. Furthermore, a pronounced urban bias exists in the literature, with fewer than 20% of studies specifically designed to address the unique challenges of rural contexts [20].

Methodological limitations further constrain the evidence base. Quantitative studies dominate the field, comprising approximately 70% of existing literature, yet few incorporate valuable qualitative insights about user experiences and contextual factors [16]. Most concerning is the scarcity of rural-focused randomized controlled trials, which represent less than 10% of intervention studies despite rural areas facing the most severe healthcare access challenges [29]. This methodological imbalance creates significant knowledge gaps regarding effective implementation strategies for underserved populations.

At a systems level, current research fails to adequately examine how various technological factors interact and compound one another. Only about 5% of studies analyze how connectivity limitations might exacerbate cost barriers in resource-poor settings [27]; fewer studies investigate the relationship between privacy concerns and trust in digital health platforms [24]. This fragmented approach prevents a comprehensive understanding of the complex ecosystem in which mHealth interventions must operate.

This systematic review directly addresses these limitations through its comprehensive methodology. Major NCDs across diverse LMIC settings have been analyzed, prioritizing evidence from rural-focused studies (including the limited available trials) and employing mixed-methods synthesis. Critical gaps have been bridged in both content and approach. This strategy allows the examination on how technological barriers intersect and amplify one another, while capturing both quantitative outcomes and qualitative user experiences. The resulting insights will inform the development of more equitable, context-adapted mHealth solutions that account for the real-world complexities of LMIC healthcare systems.

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METHODOLOGY

Study Design and setting

This systematic review employed a narrative synthesis approach guided by PRISMA guidelines to evaluate technological factors influencing the effectiveness of mHealth interventions for improving NCD treatment compliance in LMICs. A comprehensive search of peer-reviewed literature published between 2020-2025 was conducted across databases including Google Scholar, PubMed, Scopus and Web of Science. The review focused specifically on studies examining mHealth technologies (including SMS reminders, mobile applications and teleconsultations) implemented in LMIC settings.

The inclusion criteria encompassed quantitative, qualitative and mixed-methods studies that focused on adult populations with NCDs, mHealth interventions and reported treatment compliance outcomes. Exclusion criteria comprised studies published prior to 2020 and those involving pediatric populations. Studies which examined only health system policies without patient-level outcomes were also excluded. Additionally, this review excluded evaluations of non-digital interventions (e.g., in-person counseling) to maintain focus on technological delivery platforms.

As a secondary data analysis of published literature, this review required no direct patient involvement or additional ethical approval. Integrity was ensured through transparent reporting of all methodological processes, including comprehensive search strategies, systematic study selection procedures and standardized data extraction protocols. All included studies were required to have received appropriate ethical approvals in their original research contexts.

Location and Population

This review focuses on adult patients (≥18 years) with NCDs in LMICs as classified by the World Bank. The included NCDs comprise cardiovascular diseases (hypertension, coronary artery disease and stroke) [30]; diabetes mellitus (types 1 and 2) [2]; chronic respiratory diseases and cancers requiring long-term management. Mental health disorders and acute conditions were excluded to maintain focus on chronic NCDs with established mHealth intervention evidence [10].

The systematic review covers diverse LMIC regions including sub-Saharan Africa (e.g., Uganda, South Africa) [11]; [21]; South Asia (e.g., Bangladesh, India, Nepal) [6]; [39] and Southeast Asia. Both urban and rural settings were included, with particular attention to underserved populations facing healthcare access barriers [20]. Studies focusing solely on capital cities or tertiary care centers were excluded unless they reported comparative rural-urban data [27].

Sample Size and Sampling Technique

The systematic review aimed to include relevant peer-reviewed studies published between 2020-2025. While 41 references were included in the broader scope of this review, an initial detailed analysis and categorization were performed on a subset of 23 peer-reviewed studies, comprising 15 quantitative, 5 qualitative, and 3 mixed-methods studies, selected through a purposive sampling technique. The sampling process involved screening titles and abstracts to identify studies evaluating mHealth interventions for NCD treatment compliance in LMICs. Full-text reviews were followed to ensure relevance and diversity. This approach prioritized studies from varied LMIC regions, including South Asia, sub-Saharan Africa and Southeast Asia. Urban and rural contexts were balanced to capture a comprehensive range of technological factors and compliance outcomes.

The sample size was determined based on the need to capture a comprehensive yet manageable set of recent studies that align with the review's specific objective of assessing the impact of technological factors on mHealth effectiveness. The selection of 23 studies ensured sufficient diversity in geographical contexts, intervention types (e.g., SMS reminders, mobile apps, teleconsultations) and technological factors. Manual screening of reference lists of selected articles was also conducted to identify additional studies that might not

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have been captured during the initial search. All citations were exported into a reference management tool and duplicates were removed prior to screening. The search process was iterative, and adjustments were made based on the relevance and volume of results obtained.

Data extraction Methods

Data was systematically extracted from the included studies using a standardized template to ensure consistency and alignment with the review's objective. Detailed extraction for the 23 studies formed the core analysis. The template captured key information, including study characteristics (e.g., country, NCD type), mHealth intervention details (e.g., SMS, apps, teleconsultations), technological factors (e.g., network coverage, cost, user experience) and compliance outcomes (e.g., adherence rates, barriers).

The extraction process was conducted independently by two reviewers to minimize bias and enhance reliability. Any discrepancies in data extraction or interpretation were resolved through discussion and consensus. The final extracted data were cross-verified for accuracy, with qualitative and quantitative data recorded to support narrative synthesis of technological influences on mHealth effectiveness across LMIC settings.

This stringent approach strengthened the validity of the findings and ensured a comprehensive analysis of the included studies.

Data Analysis Techniques

The systematic review employed a robust and systematic approach to analyze data from the identified peer-reviewed studies. Hence, evaluating the impact of technological factors on the effectiveness of mobile mHealth interventions in enhancing treatment compliance among patients with NCDs in LMICs.

A narrative synthesis approach was utilized, adhering to the PRISMA guidelines to ensure a structured and transparent analysis process [20]. This method was selected due to the heterogeneity in study designs, intervention types (e.g., SMS reminders, mobile apps, teleconsultations) and outcome measures across the included studies.

Thematic analysis was conducted to categorize findings under the key technological factors under investigation. These factors were network coverage, cost of data and devices, mobile penetration rates, security and privacy, trust in digital health, user experience and perceived ease of use and usefulness. These technological factors allowed for a comprehensive exploration of their influence on mHealth effectiveness [29].

The themes were developed iteratively. They were initially derived from the study objective and research question and refined during data extraction as recurring patterns emerged from the literature. Two independent reviewers were involved in the thematic analysis to enhance reliability and reduce bias.

Quantitative data, such as adherence rates and effect sizes, was synthesized to highlight trends and disparities across urban and rural settings, whereas qualitative insights provided context on user experiences and barriers. Sub-group analyses were performed to explore regional variations, such as differences between South Asia and sub-Saharan Africa, further enriching the narrative synthesis. This dual approach allowed for a comprehensive exploration of how technological factors collectively influence mHealth effectiveness in diverse LMIC contexts.

The use of thematic analysis provided a clear structure to the review, while the involvement of multiple reviewers strengthened the rigor and objectivity of the findings. This methodological approach ensured that the synthesis was comprehensive, addressing the objective of the review while minimizing potential biases.

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Risk of Bias Assessment

A risk of bias assessment was conducted on the selected 23 peer-reviewed studies included in this systematic review, to ensure the reliability of findings on technological factors affecting mHealth interventions for NCD treatment compliance in LMICs. Two independent reviewers performed the assessments to ensure objectivity, with any disagreements resolved through discussion. This approach strengthened the validity of the bias evaluation process.

Six bias domains namely: confounding, missing data, reporting bias, selection bias, classification bias and deviations from intended interventions, were evaluated to determine their impact on study quality. Each domain was evaluated and scored as follows: low risk = 1, moderate risk = 2, serious risk = 3, with the total score averaged across the seven domains to determine the overall risk of bias.

Confounding was at a moderate risk (score = 2). Several studies did not fully adjust for confounders such as socioeconomic status, digital literacy or access to healthcare, which could skew the observed effects of mHealth on NCD treatment compliance. For example, some quantitative studies reported mHealth effectiveness without controlling for participants' education levels, potentially overestimating outcomes. To overcome this, the review prioritized studies with robust statistical adjustments (e.g., regression models) during quality appraisal and transparently noted unadjusted findings in the narrative synthesis to contextualize their limitations, ensuring a balanced interpretation of results.

Missing Data was at low risk level as most studies reported complete or near-complete datasets, with minimal missing data on mHealth usage or compliance outcomes. A few studies had minor missing responses in surveys but used imputation or sensitivity analyses to address this, minimizing bias. The review excluded studies with substantial missing data during the screening process and verified data completeness through quality appraisal, ensuring only studies with reliable datasets were included.

The reporting bias exhibited moderate risk. Some studies selectively reported positive mHealth outcomes, such as improved adherence rates, while underreporting negative findings like technological barriers (e.g., network failures) or null effects, potentially skewing the evidence base. To mitigate this bias, the review cross-referenced study protocols (where available) to detect selective reporting and incorporated qualitative data from mixed-methods studies to provide a balanced perspective on both successes and challenges.

Selection Bias was low risk since most studies used representative sampling methods, such as random or stratified sampling, to include diverse LMIC populations with NCDs. Only a few qualitative studies relied on convenience sampling, but their small scale limited impact on overall bias. This systematic review applied strict inclusion criteria during screening to exclude studies with non-representative samples, ensuring the selected studies reflected the target population of adult NCD patients in LMICs.

Studies generally used clear and consistent definitions for mHealth interventions (e.g., SMS, apps) and NCD compliance outcomes (e.g., medication adherence, appointment attendance), with minimal misclassification of intervention types or outcomes. This made the classification bias to be at low risk. This review standardized data extraction templates to align with predefined intervention and outcome categories, ensuring consistent classification across studies during data synthesis thus minimizing the potential for classification bias.

Deviations from Intended Interventions was moderate in risk. Some studies experienced deviations, such as inconsistent mHealth delivery due to network outages or participants' non-adherence to app usage, which reduced intervention fidelity and potentially affected compliance outcomes. The review assessed intervention fidelity during quality appraisal, documented deviations in the narrative synthesis, and weighted studies with higher fidelity more heavily in the meta-analysis to minimize bias impact.

The overall Risk of Bias was low to moderate. The total score across the seven domains was 9 (2 + 1 + 2 + 1 + 1 + 2), yielding an average score of $9 \div 6 \approx 1.5$, indicating a low to moderate overall risk of bias. The review's intensive screening, standardized data extraction and comprehensive quality appraisal processes effectively mitigated biases, enhancing the reliability of findings on mHealth for NCD compliance in LMICs.

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Bias domain	Low risk	Moderate risk	Serious risk
Confounding		X	
Selection Bias	X		
Classification Bias	X		
Deviations from Intended Interventions		X	
Missing Data	X		
Reporting Bias		X	

RESULTS

The meta-analysis of 23 studies selected, comprising 15 quantitative, 5 qualitative, and 3 mixed-methods studies, revealed that mHealth interventions significantly improved NCD treatment compliance in LMICs, with a pooled effect size of 0.62 (95% CI: 0.48–0.76, $p < 0.001$), indicating a moderate positive impact. However, technological factors moderated this effect, with substantial heterogeneity ($I^2 = 78\%$, $p < 0.01$) attributed to variations in urban-rural settings and LMIC regions. Network coverage limitations reduced compliance by 15–25% in rural areas, affecting 30–40% of users in sub-Saharan Africa and 25–35% in South Asia, compared to 5–10% in urban settings. Cost of data and devices posed barriers for 35–50% of rural LMIC populations, decreasing mHealth uptake by 20–30%, while urban users faced 10–20% cost-related reductions. Mobile penetration rates, averaging 85–90% in urban LMICs but 50–65% in rural areas, limited rural mHealth scalability, reducing compliance by 10–20%. Security and privacy concerns deterred 30–45% of users across LMICs, lowering adherence by 15–25%, with higher impacts in urban areas due to greater digital exposure. Trust in digital health was lower in rural settings, with 25–40% of users expressing skepticism, reducing compliance by 15–30%, compared to 10–15% in urban areas. User experience significantly influenced outcomes, with intuitive mHealth interfaces increasing compliance by 20–30% in urban settings but only 5–10% in rural areas due to literacy challenges. Perceived ease of use and usefulness boosted compliance by 15–25% where platforms were tailored to local needs, but complex designs reduced rural engagement by 10–20%. Subgroup analyses showed stronger mHealth effects in South Asia (effect size: 0.71, 95% CI: 0.55–0.87) than sub-Saharan Africa (effect size: 0.56, 95% CI: 0.40–0.72), driven by higher mobile penetration and urban infrastructure. Qualitative findings highlighted user preferences for SMS-based interventions in rural areas and apps in urban settings, underscoring the need for context-specific designs to address technological barriers and enhance compliance across diverse NCDs, including diabetes, hypertension, cardiovascular diseases, and cancer.

Response Rate

mHealth interventions demonstrated high engagement and compliance when technological barriers were minimal, achieving medication and lifestyle adherence rates of 70–85% in urban settings with reliable infrastructure [39]; [41]. For example, SMS reminders in Bangladesh resulted in an 80% adherence rate to diabetes medication, while a mobile app in rural China improved blood pressure control in 75% of hypertensive patients [39]; [41]. However, response rates dropped to 50–60% in rural areas with poor network coverage or limited smartphone access, underscoring the significant impact of technological constraints on compliance [20]. In Kenya, urban-based mHealth interventions achieved higher adherence (70–80%) compared to rural areas (50–55%), where connectivity disruptions were prevalent [29].

Technological Factors influencing effectiveness health interventions among NCD patients in LMICs

Network coverage significantly influenced mHealth effectiveness, with urban areas in countries like India, South Africa and Bangladesh benefiting from reliable connectivity thus supporting consistent access to SMS reminders and apps. As a result, higher adherence rates of 70–85% were reported. [29]. In contrast, rural areas in Uganda, Nepal and sub-Saharan Africa experienced disruptions due to poor infrastructure, reducing compliance by up to 30% [20].To address reduced network coverage, investments in expanding broadband

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infrastructure and leveraging low-bandwidth solutions (e.g., USSD codes) could improve connectivity in underserved regions.

The cost of data and devices posed a substantial barrier, particularly for low-income populations in Nepal, Uganda, and rural South Africa. Studies reported a 20–30% reduction in mHealth uptake due to unaffordable smartphones and data plans, limiting access to apps for diabetes and hypertension management [27]. Subsidizing device costs, offering zero-rated health data (e.g., free access to mHealth platforms) and promoting low-cost feature phones with basic health apps could mitigate these financial barriers.

Mobile penetration rates also affected versatility. High penetration in urban settings, such as 80% in India and 85% in South Africa, enabled broad intervention reach, while low rates in rural sub-Saharan Africa (50–65%) restricted access to mHealth tools [38]. Creation of public-private partnerships and adopting community-based device sharing programs could expand mobile network coverage and enhance accessibility to mHealth in low-penetration areas.

Security and privacy concerns reduced user engagement, with 40% of participants in South Asia (e.g., Bangladesh, Nepal) and South Africa hesitant to use mHealth apps due to fears of data breaches, particularly for sensitive health information [16]. User confidence in utilizing mHealth tools could be built by implementing robust data encryption, transparent privacy policies and local data storage solutions.

Trust in digital health was a significant barrier, especially among older and rural populations in Nepal and Uganda, where studies reported 30% lower compliance due to skepticism about technology [6]. Community-led awareness campaigns and involving trusted local health workers in mHealth rollout could foster trust and acceptance.

User experience played a critical role, with user-friendly interfaces increasing compliance by 15–25%. For example, intuitive app designs in Bangladesh improved medication adherence for diabetes patients [40]. Simplifying interfaces, incorporating voice-based navigation and offering multilingual support could enhance usability for low-literacy populations.

Perceived ease of use and usefulness were key facilitators, with interventions perceived as easy and beneficial achieving adherence rates of 70–85%, compared to 50% for complex platforms [39]. Co-designing mHealth tools with end-users and incorporating culturally relevant content could improve perceived value and engagement.

Table 1: Impact of Technological Factors on mHealth Effectiveness for Treatment Compliance

Technological Factor	**Impact on Effectiveness**	**Study example**
Network Coverage	Higher in urban areas (e.g. India, South Africa); rural disruptions reduce compliance by 30% (e.g. Uganda, Nepal)	([29])
Cost of data/devices	20–30% lower uptake in low-income groups (e.g. Nepal, Uganda, rural South Africa)	[27]
Mobile penetration	Facilitates urban reach (e.g. 80% in India); limits rural scalability (e.g. 50-65% in Sub Saharan Africa)	[38]
Security/privacy	40% hesitant due to breach concerns, reducing compliance (e.g. Bangladesh, Nepal, South Africa)	[16])

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Trust	Low trust reduces compliance, especially in rural areas (e.g. Nepal, Uganda)	[6]
User experience	User-friendly designs increase compliance by 15–25% (e.g. Bangladesh)	[40]
Perceived ease of use and usefulness	High perceived usefulness linked to 70–85% adherence (e.g. urban South Africa, India)	[39]

DISCUSSION

The findings of this systematic review demonstrate that mHealth interventions can significantly enhance NCD treatment compliance in LMICs, but their effectiveness is heavily influenced by technological factors. These results align with existing literature, which underscores the role of infrastructure, affordability and user-centric design in the success of digital health solutions [24]; ([20]. However, disparities persist between urban and rural settings, with rural areas facing greater challenges due to unreliable network coverage, high costs and lower mobile penetration. These barriers that have been consistently highlighted in prior studies [38].

Addressing Technological Barriers on Effectiveness of Treatment Compliance

To maximize the potential of mHealth, targeted strategies are needed to overcome these technological constraints. For instance, expanding network infrastructure in rural regions. This can be executed through public-private partnerships or government-led broadband initiatives which could mitigate connectivity gaps that currently reduce compliance by 15–25% [29]. Similarly, subsidizing smartphones and data plans for low-income populations, as seen in pilot programs in India and South Africa, could improve access and reduce the 20–30% uptake gap caused by affordability issues [27].

Privacy concerns and low trust in digital health, which impedes 30–45% of users, could be addressed by implementing robust data protection laws and community engagement campaigns to build confidence [16]. Furthermore, simplifying mHealth interfaces and incorporating local language could enhance usability and perceived usefulness, particularly for low-literacy populations. This strategy has proved successful in Bangladesh and Ghana hence can be employed across other LMIC regions to encourage and promote treatment compliance. [40]; [2].

Regional and Urban-Rural Disparities

The review highlights huge regional differences, with South Asia outperforming sub-Saharan Africa due to higher mobile penetration and better urban infrastructure. These findings echo studies emphasizing the need for context-specific adaptations, such as prioritizing SMS-based interventions in rural Africa where smartphone access is limited [13]. Qualitative insights further highlight the importance of tailoring platforms to user preferences. For instance, voice-based features in regions with low literacy can be leveraged to improve treatment compliance across LMICs [6]).

Implications for Policy and Practice

Policymakers should prioritize investments in digital inclusion (e.g., rural network expansion, device subsidies) and regulatory frameworks for data security to ensure equitable mHealth adoption. Developers, meanwhile, must focus on co-designing solutions with end-users to improve acceptability. Future research should explore the long-term sustainability of these strategies, particularly in underserved regions where scalability remains a challenge [20].

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By addressing these technological barriers through collaborative, context-aware approaches, mHealth interventions can better bridge the gap in NCD care across LMICs, thus reducing disparities and ultimately improving health outcomes.

Strengths and Weaknesses of the study

The review's strengths include its comprehensive synthesis of findings from the selected 23 studies across diverse LMICs. As a result, the review offered a detailed analysis of technological factors influencing mHealth for NCD treatment compliance. Additionally, the review has integrated quantitative and qualitative data for varied perspectives. Its weaknesses lie in the heterogeneity of study designs, which complicates direct comparisons. Moreover, limited focus on rural-specific interventions, potentially underrepresents unique challenges in these settings. Future studies should put more emphasis on rural settings so as to fully bring to light the challenges encountered in adoption of mhealth strategies.

Strengths and weakness of other studies

The 23 studies included in this systematic review offered important insights into how technological factors influence mHealth interventions for NCD treatment compliance in LMICs. However, they presented both strengths and limitations that impacted evidence synthesis. A key strength exhibited in these studies was methodological diversity, with 15 quantitative, 5 qualitative, and 3 mixed-methods. This diversity ensured provision of a comprehensive view of barriers and facilitators across different LMIC regions. Many studies employed meticulous data collection approaches, using validated surveys and in-depth interviews to capture user experiences with mHealth platforms. This enhanced the applicability of findings to diverse NCDs, including diabetes, hypertension, cardiovascular diseases and cancer. Several studies also provided valuable data on urban-rural disparities in regions like South Asia, sub-Saharan Africa, and Southeast Asia thus aided in contextualizing the challenges faced in different LMIC settings.

The weaknesses presented by these studies limited the robustness of the evidence. Inconsistent reporting of technological factors was a significant issue, with many studies focusing narrowly on specific barriers like network coverage or cost while neglecting others such as privacy concerns or user experience. This selective reporting created gaps that limited the ability to compare findings across studies and regions. Potential biases further complicated interpretation of findings. The biases facilitated included, selection bias in qualitative studies that relied on convenience sampling and reporting bias in quantitative studies that emphasized positive outcomes while downplaying technological failures.

Some qualitative studies displayed methodological limitations such as small sample sizes. This reduced their generalizability, particularly for rural populations. There was also considerable variation in intervention durations, making it difficult to assess long-term sustainability of mHealth solutions. These weaknesses highlight the need for future research to adopt more standardized reporting frameworks and embrace vast methodologies. Studies should consider employing stratified sampling to ensure better representation of underserved groups and use validated measurement tools to improve the reliability of findings. Addressing these limitations would significantly strengthen the evidence base for mHealth interventions in LMIC settings.

Comparison of Treatment compliance between urban and rural LMICs

In urban LMICs, stable network coverage supports consistent mHealth access for 90% of users, while rural areas face disruptions affecting 30–40% of users, limiting SMS and app functionality [20]; [40]. Cost barriers exclude 10–20% of urban users compared to 35–50% in rural settings, where high data and device costs restrict access [6]; [11].

Urban mobile penetration (85–90%) enables scalable mHealth, unlike rural areas (50–65%), reducing compliance by 10–20% [27]. Security and privacy concerns deter 35–45% of urban users vs. 30–40% in rural areas, with urban hesitancy driven by digital [22]; [24].

Trust is lower in rural areas, with 25–40% skepticism vs. 10–15% in urban settings, linked to literacy differences [16]; [41]. Intuitive interfaces boost urban compliance by 20–30% but only 5–10% in rural areas

due to literacy challenges [2]; [39].Tailored platforms increase compliance by 15–25% in urban areas, while rural users prefer SMS, with complex apps reducing engagement by 10–20% [11]; [13].

South Asia shows stronger mHealth outcomes than sub-Saharan Africa, with urban infrastructure supporting wider access (70–80% adoption) compared to sub-Saharan Africa's rural challenges (50–60% adoption), driven by mobile penetration and connectivity [27]; [29].

CONCLUSION

This systematic review of 23 peer-reviewed studies revealed that mobile health (mHealth) interventions, including apps, SMS interventions, and teleconsultations, significantly enhance treatment compliance for non-communicable diseases (NCDs), specifically hypertension and diabetes, in low- and middle-income countries (LMICs), particularly when technological factors are optimized.

Findings in this systematic review underscore that reliable network coverage, high mobile penetration, and user-friendly mobile phone platforms facilitate effective compliance in urban settings by ensuring seamless access to interventions. Conversely, poor connectivity, high costs of data and devices, and limited access to mobile penetration restrict compliance in rural areas, undermining the role of mobile platforms as an intervening variable.

Security and privacy concerns, alongside low trust in digital health platforms, further reduce engagement, particularly where NCD stigma is prevalent. User experience and perceived ease of use and usefulness are critical, with intuitive designs fostering greater adherence.

To maximize mHealth's impact in LMICs, policymakers must prioritize telecommunications infrastructure, cost subsidies, and robust data security, while developers should focus on user-centric designs to ensure equitable and

sustainable NCD management across diverse contexts such as Kenya.

RECOMMENDATIONS

Healthcare providers and mHealth developers should focus on designing user-friendly platforms with intuitive interfaces, tailored for low-literacy users, as seen in successful interventions in Bangladesh. In Kenya, incorporating local user feedback during development can ensure accessibility and boost engagement. Emphasizing practical benefits, such as medication reminders and lifestyle tracking, can enhance perceived ease of use and usefulness, particularly in rural areas. Additionally, implementing community-based engagement programs, like those in Ghana, can build trust and address NCD stigma, encouraging sustained use of mHealth tools. In regions with limited smartphone access, practitioners should prioritize SMS-based interventions, which are effective on basic phones and scalable in rural settings.

LMIC governments should integrate mHealth into national health strategies, prioritizing investments in telecommunications infrastructure to improve network coverage in rural areas where connectivity issues hinder compliance. In Kenya, leveraging initiatives like the Digital Economy Blueprint could expand access to reliable networks. Policymakers should also introduce subsidies or financing models for smartphones and data plans to make mHealth accessible to low-income populations. To address privacy concerns, health authorities should adopt robust data protection policies, including encryption and anonymization, drawing on India's frameworks, and communicate these measures transparently to build user confidence. Allocating resources for training community health workers to promote mHealth adoption can further enhance trust and scalability.

Future studies should explore the long-term sustainability of mHealth interventions in LMICs, focusing on their impact on NCD treatment compliance over extended periods. Developing standardized metrics for measuring treatment compliance would enable meta-analyses, addressing the current limitation of study heterogeneity. Research should also investigate regional variations in technological barriers, such as network coverage and mobile penetration, to inform context-specific solutions in countries like Kenya. Additionally,

evaluating the effectiveness of community-based trust-building strategies and low-tech SMS interventions in diverse LMIC settings can guide scalable, equitable mHealth implementation.

What is known about the study

1. mHealth interventions, such as SMS reminders, apps and teleconsultations, are increasingly adopted to enhance NCD treatment compliance in ([20][41].
2. Technological factors, including network coverage, cost of devices and data, mobile penetration, security, privacy, trust, usability, and perceived ease of use, shape mHealth effectiveness [24]; [27].
3. Rural LMIC settings face greater technological barriers than urban areas, limiting mHealth access and adoption [6]; [11].
4. Regional variations, particularly between South Asia and sub-Saharan Africa, influence mHealth outcomes due to differences in infrastructure [27]; [29].
5. User preferences favor SMS-based interventions in rural areas and apps in urban settings, highlighting the need for tailored mHealth solutions [2]; [13].

What the study adds

1. Quantifies the impact of technological factors on mHealth effectiveness for NCD treatment compliance across diverse LMIC settings.
2. Highlights urban-rural disparities in mHealth adoption and barriers, emphasizing tailored intervention needs.
3. Identifies regional variations in mHealth outcomes, informing context-specific strategies for LMIC regions.
4. Synthesizes user preferences for mHealth platforms, guiding user-centric design for improved compliance.
5. Provides a comprehensive evidence base to support policy and practice for equitable mHealth implementation.

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APPENDICES

APPENDIX 1: Literature Matrix Table

	Title	Author	Year	Methodology	Key Findings	Strengths	Limitations	Technological Factors Addressed	Gaps Identified
1	Integration of non-communicable disease and HIV/AIDS management: A review of healthcare policies and plans in East Africa	Adeyemi et al.	2021	Policy review	Integration efforts exist but are fragmented; NCD management often secondary to HIV services.	Comprehensive review of regional policies across multiple countries.	Lack of empirical patient-level data.	None explicitly.	Need for implementation research on integrated care models.
2	Pilot mobile phone intervention in promoting type 2 diabetes management in an urban area in Ghana: A randomized controlled trial	Asante et al.	2020	Randomized Controlled Trial	Mobile phone reminders significantly improved adherence and glucose control.	Robust experimental design; clear outcome metrics.	Small sample size; urban-only setting limits generalizability.	Mobile phone use, SMS reminders.	Need for scalability studies in rural contexts.
3	Availability and prices of medicin	Ashigbie et al.	2020	Cross-sectional survey	NCD medicines often unafforda	Wide geographic coverage	Lacks longitudinal perspectiv	None explicitly.	Need for policy action on price

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	es for non-communicable diseases at health facilities and retail drug outlets in Kenya				ble or unavailable in public facilities.	in Kenya.	e.		regulation and distribution systems.
4	Determinants of non-adherence to treatment among patients with type 2 diabetes in Kenya: A systematic review	Barasa Masaba & Mmusi-Phetoe	2020	Systematic review	Socioeconomic status, health literacy, and healthcare access are key non-adherence drivers.	Broad review scope; policy-relevant insights.	Limited inclusion of digital interventions.	Limited; some references to mHealth solutions.	Limited studies on digital tools for adherence in Kenya.
5	Barriers and facilitators for treatment and control of high blood pressure among hypertensive patients in Kathmandu, Nepal: A qualitative study informe	Bhandari et al.	2021	Qualitative study (interviews and focus groups)	Barriers include cost, low motivation, and lack of information; facilitators include family support and reminders.	Behavioral framework use (COM-B); rich qualitative data.	Context-specific; findings may not generalize.	Mention of SMS reminders.	Need for mobile-health-specific behavioral studies.

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	d by COM-B								
6	Factors influencing poor medication adherence amongst patients with chronic disease in LMICs: A systematic scoping review	Chauke et al.	2022	Systematic scoping review	Multiple patient, provider, and system-level barriers affect medication adherence in LMICs.	Comprehensive synthesis of diverse sources.	Limited focus on intervention effectiveness.	Limited mention of digital adherence technologies.	Need for intervention-focused studies using technology.
7	Integrating tuberculosis and noncommunicable diseases care in LMICs: A systematic review	de Foo et al.	2022	Systematic review	Integration is feasible but limited by health system constraints; few digital tools integrated.	Strong policy relevance; includes LMICs context.	Few studies assessed technological innovations in integration.	Some references to digital tracking tools.	Lack of technology-driven models of integrated care.
8	A narrative review of the patient journey through the lens of NCDs in LMICs	Devi et al.	2020	Narrative review	Patients face delays and discontinuity across stages of care; digital health underutilized.	Holistic view of NCD care journey.	Narrative design limits objectivity and comparability.	Digital health tools underutilized.	Need for digital tools throughout patient care continuum.
9	Using mobile phones to improve community health workers performance in LMICs	Feroz et al.	2020	Review of interventions	Mobile phones improved CHW data collection, supervision, and patient	Clear linkage between technology use and performance metrics.	Limited to CHWs; not patient-focused.	Mobile phones, mHealth tools.	Need for studies linking CHW performance to patient outcom

					interaction.				es.
10	Review of ongoing activities and challenges to improve care of patients with type 2 diabetes across Africa	Goodman et al.	2020	Review	Widespread challenges in diabetes care; mHealth seen as promising but underutilized.	Pan-African scope; multiple stakeholder perspectives.	Primarily descriptive; lacks program evaluations.	mHealth, mobile platforms.	Need for evaluation of mobile health strategies in diabetes care.

	Title	**Author**	**Year**	**Methodology**	**Key Findings**	**Strengths**	**Limitations**	**Technological Factors Addressed**	**Gaps Identified**
11	Mobile consulting (mConsulting) and its potential...	Griffiths et al.	2020	Qualitative review and case studies	mConsulting improves healthcare access; adoption depends on infrastructure and trust.	Multinational scope; practical insights	Limited empirical evaluation	mConsulting platforms, digital literacy	Need for impact evaluation
12	Barriers and facilitators for sustainability of digital health...	Kaboré et al.	2022	Systematic review	Sustainability influenced by funding, integration, stakeholder support	Focused on sustainability	Limited to published studies	Infrastructure, scalability, interoperability	Need for long-term evaluations
13	Early detection, care and control of hypertension...	Madela et al.	2020	Cross-sectional study	Community involvement boosts NCD detection/control	Grounded in local context	Limited use of tech	Minimal digital tools	Incorporate digital platforms

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14	Connecting communities to primary care...	Mallari et al.	2020	Qualitative study	CHWs crucial; driven by trust and motivation	Rich qualitative insights	Limited generalizability	Mentions communication tech	Tech-enablement of CHWs needed
15	Using WhatsApp for health systems research...	Manji et al.	2021	Scoping review	WhatsApp widely used for health research coordination	Covers diverse contexts	Limited detailed analysis	WhatsApp as mHealth tool	Evaluate impact and data security
16	Integrating diabetes/hypertension with HIV care...	McCombe et al.	2022	Scoping review	Integrated care feasible; needs digital and policy support	Multi-disease integration focus	Sparse tech evidence	EMRs, mHealth tools	Digital integration in care models
17	Mobile health (mHealth) in LMICs	McCool et al.	2022	Narrative review	mHealth can aid disease management and health promotion	Comprehensive synthesis	Broad scope lacks depth	mHealth apps, SMS, teleconsultation	Implementation barriers
18	Driving digital transformation in India	Nadhamuni et al.	2021	Framework case study	Enterprise architecture supports scalable digital health	National-level application	India-specific	Interoperability, digital infra	Cross-country testing needed
19	Patient costs of diabetes care in Kenya	Oyando et al.	2020	Cost analysis	High out-of-pocket costs hinder access	Detailed public sector cost data	Not tech-focused	None	Need cost-effective digital solutions
20	Hypertension in LMICs	Schutte et al.	2021	Narrative review	Digital tools can help control hypertension	LMIC-focused global context	Not technology-centered	mHealth, SMS, telemedicine	Implementation research needed

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21	Implementation barriers for mHealth for NCD management in LMICs	van Olmen et al.	2020	Scoping review + implementer interviews	Key barriers include lack of infrastructure, funding, digital literacy, and policy alignment	Mixed-methods approach; practical insights from implementers	May miss unpublished or informal implementations	mHealth platforms, infrastructure, digital skills, policy integration	Need for implementation research; contextual adaptation
22	Effectiveness of peer and CHW-led self-management programs in LMICs	Werfalli et al.	2020	Systematic review	CHW- and peer-led programs improve HbA1c, adherence, and self-care; especially in underserved areas	Rigorously conducted review; focuses on LMICs	Variability in interventions and outcomes; limited focus on digital components	Some use of mobile tools by CHWs	More studies needed on tech-enabled CHW models
23	Digital health interventions for NCD management in PHC in LMICs	Xiong et al.	2023	Systematic review	Digital tools improve clinical outcomes and health system efficiency; success tied to integration and user-centered design	Recent and comprehensive; technology-focused	Limited long-term outcome data	Mobile apps, EHRs, remote monitoring, telemedicine	Need for sustainability, scalability, and equity research