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Enhancing Healthcare Delivery Through Digital Health Interventions: A Systematic Review on Telemedicine and Mobile Health Applications in Low and Middle-Income Countries (LMICs)

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Systematic Review

Keywords: Telemedicine, Mobile Health (mHealth), Healthcare Delivery, Low- and Middle-Income Countries (LMICs), Healthcare Access, Technology Adoption, Resource-Limited Settings

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Enhancing Healthcare Delivery Through Digital Health Interventions: A Systematic Review on Telemedicine and Mobile Health Applications in Low and Middle-Income Countries (LMICs)

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Abstract

This study explores the role of telemedicine and mobile health (mHealth) technologies in improving healthcare delivery within low- and middle-income countries (LMICs). A thorough review of existing literature reveals that these technologies have made significant strides in enhancing healthcare access, diagnostics, and patient outcomes, particularly in underserved and remote areas. Key findings indicate that telemedicine has played a crucial role in enabling early disease detection, boosting maternal and child health, and promoting improved medication adherence among patients. Nevertheless, the study also uncovers significant barriers that impede the effective implementation of these technologies, including inadequate infrastructure, unreliable internet connections, limited digital literacy, regulatory challenges, lack of funding, and a shortage of trained healthcare professionals. Additionally, the review notes its limitations, such as the omission of grey literature and inconsistencies in regional research coverage, which may impact the overall findings. To address these challenges, the study emphasises the need for LMICs to invest in technological infrastructure, improve digital literacy, create comprehensive regulatory frameworks, and secure sustainable funding sources. Furthermore, integrating telemedicine into national healthcare strategies and enhancing public awareness are critical steps to fully leverage the advantages of these technologies, ultimately fostering equitable healthcare access and improved health outcomes in resource-constrained environments.

Keywords: Telemedicine, Mobile Health (mHealth), Healthcare Delivery, Low- and Middle-Income Countries (LMICs), Healthcare Access, Technology Adoption, Resource-Limited Settings.

1. Introduction

Global healthcare management is confronted with profound challenges, particularly in Low and Middle-Income Countries (LMICs), where access to and quality of healthcare are frequently undermined by geographical, economic, and infrastructural limitations (WHO, 2019). In response, digital health interventions such as telemedicine and mobile health (mHealth) applications have emerged as transformative solutions, potentially enhancing healthcare delivery, patient outcomes, and overall system efficiency (Labrique et al., 2013).

Telemedicine, in particular, refers to using electronic information and communication technologies (ICT) to deliver healthcare services across geographical distances (Khan, 2020). It facilitates the provision of medical services, the exchange of medical data, and the dissemination of medical education, either in real-time (synchronous) or through store-and-forward methods. As technological advancements accelerate, healthcare systems are increasingly integrating innovative solutions such as robotics, blockchain, artificial intelligence (AI), the Internet of Medical Things (IoMT), wearable technologies, smart devices, and high-speed internet connectivity, all of which are transforming and disrupting traditional healthcare models (Khan, 2020; Keshvardoost et al., 2020). These technologies offer unprecedented opportunities for delivering healthcare services through modalities like remote patient monitoring (RPM), virtual consultations, and mobile health (mHealth) platforms (Keshvardoost et al., 2020). The expanding landscape of telemedicine topology, architecture, and platforms not only enhances accessibility but also addresses the increasing demands for safety, quality, and scope for both healthcare providers and users (Helou et al., 2020; Mann et al., 2020).

Moreover, telemedicine and mobile health platforms have been adopted and utilised since the COVID-19 pandemic. The use of mobile health applications and telemedicine in preventing the spread of infectious diseases in LMICs is not unprecedented (Mahmoud et al., 2022). Telemedicine services have been successfully deployed in managing previous outbreaks, such as the severe acute respiratory syndrome (SARS) in 2003 and the Middle

East Respiratory Syndrome (MERS) in 2015, significantly enhancing the healthcare system's responsiveness (Khan, 2020). During the Ebola outbreak in Africa between 2014 and 2016, telemedicine played a pivotal role, mainly through an innovative mobile application for Ebola contact tracing. This technology-enabled remote monitoring and tracking of patients, effectively reducing virus transmission by preventing further spread from infected individuals (Keshvardoost et al., 2020).

This development is especially critical, as telemedicine helps to bridge the social, economic, and geopolitical barriers between patients and healthcare providers, fostering more personalised care (Asante et al., 2016). This is particularly relevant in LMICs, where healthcare systems grapple with limited workforces, brain drain, and constrained health budgets (Caetano et al., 2020). As life expectancy rises and the dual burden of infectious and noncommunicable diseases intensifies, the strain on healthcare systems in LMICs will only worsen (Hoffer-Hawlik; Kaeley et al., 2021).

Telemedicine holds the potential to dramatically expand healthcare access for millions globally when effectively implemented (Bokolo, 2020). With over 816 million mobile connections by 2019, projected to reach 1.05 billion by 2025, the widespread use of mobile devices will not only facilitate the deployment of telemedicine services worldwide but also enable the delivery of personalised healthcare (Bokolo, 2021; Giacalone et al., 2022). Investing in the full spectrum of telemedicine—spanning hardware, software, and regulatory frameworks—can supplement the existing healthcare workforce, improve efficiency, and significantly enhance access to care (Munn et al., 2018).

Likewise, mobile health applications have gained recognition as a cost-effective and accessible solution for delivering high-quality healthcare services, particularly in LMICs with fragile health systems, high rates of tropical and infectious diseases, and elevated mortality (WHO, 2016). Although mHealth initiatives are more prevalent in high-income countries (HICs) where they have transformed healthcare delivery (Osei & Mashamba-Thompson, 2021), there is a growing trend in integrating mobile health applications into the broader eHealth frameworks of LMICs (Sondaal et al., 2016), driven by the rapid increase in mobile phone penetration and societal acceptance (GSMA, 2019). As such, mobile phones can reach more of the population in resource-constrained environments than traditional healthcare delivery methods. The conventional use of mobile phones for

communication via text messages has evolved, with these devices now being employed to support healthcare delivery (Castelnuovo et al., 2015).

Despite the promise offered by digital health interventions, substantial evidence gaps persist regarding their effectiveness, feasibility, and scalability in LMICs, especially in Africa (Huang et al., 2020). These gaps present obstacles to the optimal implementation and integration of these technologies within existing healthcare infrastructures, thus limiting their overall impact (Mechael et al., 2010).

Nevertheless, incorporating telemedicine and mobile health applications into clinical practice within LMICs such as Kenya has the potential to reduce costs and conserve healthcare resources in the long term, ultimately lessening the reliance on out-of-pocket payments and improving access to affordable care for the population (Mahmoud et al., 2022). This is particularly important in LMICs, where out-of-pocket expenditures constitute a significant portion of total healthcare spending, as general health insurance coverage is often unavailable (Asante et al., 2016).

However, there remains a dearth of research on the availability and utilisation of telemedicine and mobile health applications for enhancing healthcare delivery in LMICs, with limited insights into the barriers and enablers of these technologies in these regions. Therefore, extensive research is needed to evaluate the effectiveness of these interventions and establish frameworks that will facilitate their successful adoption. This study's primary objective was to map the existing literature on telemedicine to assess its scope and reach within LMICs.

This research addresses a critical problem in global healthcare management by leveraging digital health interventions to improve access to and quality of healthcare services in LMICs. Telemedicine and mHealth applications can potentially bridge the healthcare gap caused by geographical, economic, and infrastructural limitations (WHO, 2019). The study will fill an evidence gap by providing data on these interventions' effectiveness, feasibility, and scalability in resource-limited settings (Labrique et al., 2013). To achieve this, the study will focus on the following research objectives:

i. Identify and evaluate the effectiveness of telemedicine and mobile health (mHealth) applications in improving healthcare delivery in LMICs.

ii. Assess the barriers and facilitators to implementing digital health interventions in these settings.

2. Methods

2.1 Methodology

This review adopted a systematic literature review approach guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework. While PRISMA 2020 is primarily tailored for systematic reviews evaluating health interventions, its applicability extends to reviews of various other interventions, including those in social and educational domains (Sohrabi et al., 2021). The PRISMA guidelines enhance the methodological rigour of identifying, selecting, and synthesising relevant studies, thereby improving the overall quality and transparency of the review process (Page et al., 2021).

2.2 Search Strategy

To address the research objectives, a comprehensive and methodologically robust search strategy was employed across several databases, including Wiley, PubMed and Springer Link. Additionally, a rigorous hand search was conducted to identify relevant grey literature, including project evaluation reports, thus ensuring the inclusion of non-indexed but significant sources for the introductory and discussion sections. To facilitate the online search, meticulously formulated search strings incorporating Boolean operators (OR/AND) were utilised across the electronic databases. The keyword strings deployed in this process included a broad range of terms such as telehealth, telemedicine, digital health, remote care, hospital-at-home, digitalised healthcare, digitalised medical care, virtual healthcare, virtual medical care, teleconsultation, videoconferencing, as well as terms pertaining to less developed countries, including least economically developed countries, non-industrialised nations, lower-middle-income countries, global south, developing countries, underdeveloped nations, and third-world countries or nations. Furthermore, the search encompassed a variety of research publications, including both conference proceedings and journal articles, ensuring comprehensive coverage of the relevant literature.

The searches were conducted between 3rd July 2024 and 27th August 2024. An illustrative example of one of the search strings utilised can be found in ***Supplementary***

File 1. ***Figure 1*** depicts the study's search phases, which adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) framework, ensuring a transparent and replicable process. The initial search results yielded 353 articles based on the specified keywords. After removing duplicate papers, 268 articles remained. These were further evaluated using predefined inclusion and exclusion criteria (***see Table 1***). In addition, to mitigate potential bias, each publication underwent an independent evaluation by the authors (Dr Lawrence Jones-Esan (LJE), Dr Nalinda Somasiri (NS)). The full-text screening, however, was conducted solely by the first author (LJE). Predetermined inclusion and exclusion criteria systematically directed the screening process. In instances of disagreement, resolution was achieved through collaborative discussion. Ultimately, 71 articles met the criteria, with an additional 15 papers identified through the snowballing technique via cross-referencing. Consequently, 86 papers were included in the final review, as reflected in the reference section.

2.3 Inclusion and Exclusion Criteria

The studies selected for inclusion in this review were restricted to those conducted between 2014 and 2024, with a specific focus on developing and utilising telemedicine platforms within Low- and Middle-Income Countries (LMICs), as classified by the World Bank. This category encompasses countries designated as low-income (LICs), lower-middle-income (LMIs), and upper-middle-income (UMICs) (World Bank, 2023). Only peer-reviewed articles published in English were considered, provided they involved any form of medical intervention facilitated by hospitals, clinics, or healthcare providers through telemedicine platforms or mobile health applications accessible to patients. The scope of telemedicine services covered in these studies included diagnosis, treatment, and disease prevention delivered via voice calls, video calls, or text messaging services. Furthermore, the review embraced all facets of healthcare delivery, incorporating mental health, dental care, nursing, and rehabilitation services, thus ensuring a comprehensive evaluation of telemedicine's role across various medical disciplines.

Table 1: Inclusion and Exclusion Criteria

Criteria	Inclusion	Exclusion

Time Frame	Studies published from 2014 to date	Studies published before 2014
Geographical Focus	Low- and Middle-Income Countries (LMICs), including LICs, LMIs, and UMICs as defined by the World Bank (2023)	High-income countries (HICs) or countries not classified as LMICs
Language	Peer-reviewed articles published in English	Articles not published in English
Medical Interventions	Studies involving telemedicine platforms for any medical intervention, including hospitals, clinics, and healthcare providers	Studies not involving telemedicine or those without any medical intervention
Telemedicine Services	Telemedicine services and mobile health applications used for diagnosis, treatment, and disease prevention via voice calls, video calls, or text messaging	Telemedicine services that do not involve patient reachability or that do not include diagnosis, treatment, or prevention
Healthcare Areas	All aspects of healthcare, including mental health, dental care, nursing, and rehabilitation	Studies limited to non-healthcare sectors, or excluding mental health, dental, nursing, and rehabilitation
Telemedicine Platforms	Studies involving mobile health applications or platforms accessible to patients	Studies not involving patient-accessible mobile health applications or telemedicine platforms
Study Type	Peer-reviewed research articles including quantitative, qualitative,	Non-peer-reviewed articles, editorials, opinion pieces, and

	trial, and experimental studies that provides evidence	grey literature not meeting other inclusion criteria

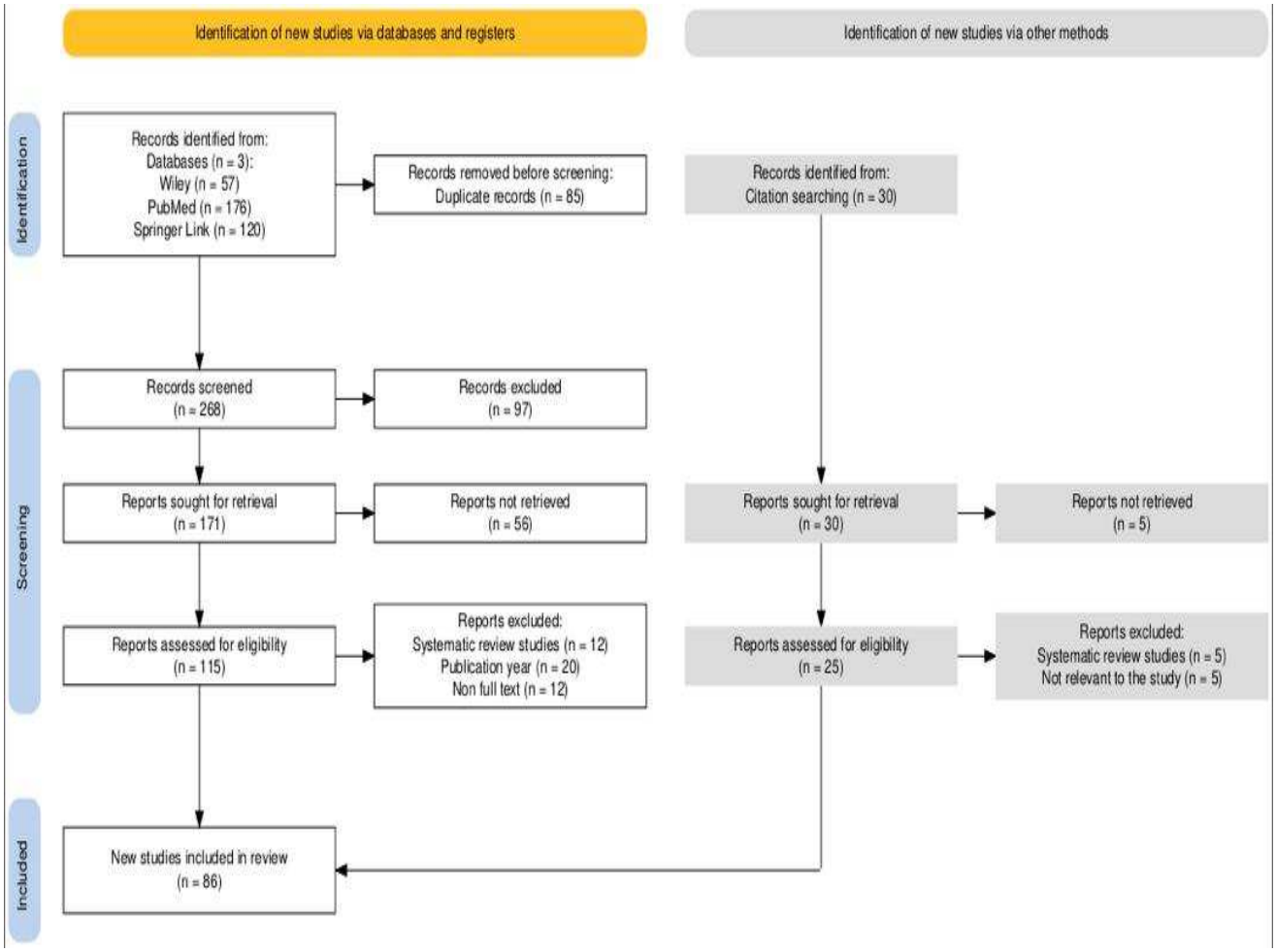

Figure 1: PRISMA Flow Chart

2.4 Eligibility Assessment

The identified references were systematically exported into Covidence (Covidence.org), and any duplicates were removed to ensure data accuracy. The title and abstract screening process was conducted in two distinct stages. The first stage involved an independent review to exclude articles that clearly met the predefined exclusion criteria, ensuring a thorough initial screening. This was followed by a second stage, where a comprehensive independent screening of the remaining articles was undertaken, evaluating each against both the inclusion and exclusion criteria. After this rigorous two-stage process, a comprehensive full-text screening of the selected articles was performed to further refine the selection.

2.5 Data Extraction

Data extraction was carried out independently and in parallel with the quality assessment process, ensuring thoroughness and consistency. Each article was subjected to two independent data extraction forms, and any discrepancies between the forms were resolved through comparison and harmonisation, maintaining the objectivity of the process. Where inconsistencies persisted, the original articles were revisited to ensure accuracy. The studies included in the review were subsequently categorised based on several key criteria, including their geographical distribution (country or countries), the primary topics discussed (illness/treatment), the study methods and designs employed, and the key findings.

2.6 Search Results

A total of 353 electronic articles were retrieved from the databases searched, with the following distribution: Wiley (=57), PubMed (=176) and Springer Link (=120). Of the 353 articles initially identified, 85 were found to be duplicates and subsequently removed, leaving 268 articles. A further 197 articles were excluded based on their titles and/or abstracts, as they did not meet the inclusion criteria outlined in Section 2.3. Consequently, 71 articles were selected for full-text review, of which an additional 15 were identified through the snowballing technique via cross-referencing. As a result, 86 articles were included in the final review (see Table 2 for a summary of the included articles).

Of the 86 included articles, 9 studies were conducted in India, while 7 were conducted in Kenya and South Africa. Six studies were conducted in Nigeria and 5 in Ghana.

Additionally, 4 studies took place in Uganda, Ethiopia, and China. Two studies were conducted in each of the following countries: Libya, Mexico, Brazil, Tanzania, Argentina, Malaysia, Zimbabwe, Mozambique, Malawi, Egypt, and Madagascar. Moreover, a single study was conducted in each of the following: Pakistan, Côte d'Ivoire, Lesotho, Palestine, Bangladesh, Guatemala, Vietnam, Ecuador, Peru, Colombia, Lebanon, Thailand, Iran, Sierra Leone, Congo, and the Philippines.

Author and Year	Country	Main topic, Health Problem	Method/Design	Key Findings
Lund et al. (2014)	**Tanzania**	**Association between a mobile phone intervention and antenatal care in a resource-limited setting**	**Open-label pragmatic cluster-randomised controlled trial**	**Mobile phone intervention was associated with an increase in antenatal care attendance**
Liu and Lin (2014)	**Uganda**	**To identify how current mHealth programs are being utilised in rural clinics and what improvements can be made**	**Key informant interviews and focus groups**	**Using mHealth services, access to medications are improved in remote, low-resource communities**
Catalani et al. (2014)	**Kenya**	**Integrating Tuberculosis and HIV Care**	**Human-centred design**	**The human-centred design facilitated the process of digital innovation in a complex and resource-constrained context**

Khonsari et al. (2015)	**Malaysia**	**SMS for improved medication adherence**	**Interventional study**	**Automated SMS-based reminder systems can potentially enhance medication adherence in ACS patients during the early post-discharge period in low-resource settings.**
Cormick et al. (2015)	**Argentina**	**Acceptability, utilisation, and barriers of an SMS-based appointment reminder to confirm a post-partum home visit to women in Tucumán, Argentina**	**Observational study**	**There was a general widespread acceptance and utilisation of mHealth among this group of women with access to cell phones.**

Kamal et al. (2015)	**Pakistan**	**To test the effectiveness of SMS on improving medication adherence in stroke survivors in Pakistan**	**Randomised controlled trial**	**Customised SMS interventions can improve medication adherence and lower diastolic blood pressure in stroke survivors with complex regimens in resource-poor areas, showing the potential of low-cost mobile health solutions.**
McNabb et al. (2015)	**Nigeria**	**Assessment of the impact of the introduction of the CommCare mobile app on the quality of antenatal care in low-resource settings**	**Pre-test/post-test study**	**The introduction of a low-cost mobile case management and decision support application can spur behaviour change and improve the quality of services provided by a lower-level cadre of healthcare workers.**

Raghu et al. (2015)	**India**	**Development and pilot testing of SMARTHealth, a mobile-based, point-of-care Clinical Decision Support (CDS) tool to assess and manage cardiovascular disease (CVD) risk in resource-constrained settings.**	**User-centred design approach**	**The CDS tool was found to be feasible for use and easily integratable into the workflow of healthcare workers.**
Smith et al. (2015)	**India**	**To assess the potential for using mHealth in cardiovascular disease (CVD) management**	**Qualitative, semi-structured, individual interviews**	**mHealth tools were found to improve accessibility to healthcare knowledge; provide reminders of appointments, medication and lifestyle changes; save time, money and travel; and improve ASHA job efficacy**

Ephraim et al. (2015)	**Ghana**	**Evaluation of Mobile Phone-Mounted Foldscope and a Reversed-Lens CellScope for the diagnosis of *Schistosoma haematobium* Infection**	**Epidemiologic survey**	**These two novel devices show early promise and may be a stepping stone for future portable diagnostic devices.**
Bobrow et al. (2016)	**South Africa**	**Assessment of the effect of automated treatment adherence support delivered via mobile phone short message system (SMS) text messages on blood pressure**	**Pragmatic, single-blind, 3-arm, randomised trial**	**There was a small reduction in systolic blood pressure control compared with usual care at 12 months.**

Coulibaly et al. (2016)	**Côte d'Ivoire**	**Impact of handheld light microscopy using compact optics and mobile phones in resource-constrained settings**	**Cross-sectional study**	**Handheld light microscopy using compact optics and mobile phones may improve the quality of health care in resource-constrained settings by enabling access to prompt and accurate diagnosis.**
Haberer et al. (2016)	**Uganda**	**To explore the effects of four types of short message service (SMS) plus real-time adherence monitoring on antiretroviral therapy (ART) adherence**	**A pilot randomised controlled trial.**	**Scheduled SMS reminders improved ART in the context of real-time monitoring.**

Mugo et al. (2016)	**Kenya**	**Evaluating the effect of SMS, phone calls and in-person reminders on uptake of repeat HIV testing among outpatients evaluated for AHI in Coastal Kenya.**	**Randomised controlled trial**	**Appointment reminders through SMS, phone calls and in-person reminders increased the uptake of repeat HIV tests by forty per cent.**
Toda et al. (2016)	**Kenya**	**To test the effectiveness of a text-messaging system used for notification of disease outbreaks in Kenya**	**Randomised controlled trial**	**The study found that technology in the form of mSOS can increase the rate of notifications of suspected disease outbreaks and enhance IHR compliance in resource-limited settings.**
Mtema et al. (2016)	**Tanzania**	**Developing and deploying a large-scale rabies surveillance system based on mobile phones.**	**Intersectoral mobile-phone–based surveillance system**	**Mobile technologies can significantly improve health system surveillance**

Brinkel et al. (2017)	**Ghana**	**To investigate and determine the factors that enhanced or constituted barriers to the acceptance of an mHealth system.**	**Four semi-structured focus group discussions**	**Results revealed 10 categories of factors that facilitated user acceptance of the IVR system, including quality-of-care experience, health education and empowerment of women.**
Georgette et al. (2017)	**South Africa**	**Impact of a clinical program using weekly Short Message Service (SMS) on antiretroviral therapy adherence support.**	**A retrospective cohort study**	**Exposure to the SMS program was independently associated with greater prescription coverage compared with non-exposure**
Hirsch-Moverman et al. (2017)	**Lesotho**	**Impact of mHealth for enhancing patient-provider communication for HIV/TB Treatment Support**	**Mixed methods**	**The mHealth intervention for HIV/tuberculosis treatment support in Lesotho was found to be a low-tech, user-friendly intervention, which was acceptable to patients and healthcare providers.**

Kazi et al. (2017)	**India**	**To assess the effect of mobile technology to optimise disease surveillance and healthcare delivery at mass gatherings**	**An inexpensive, tablet-based customised disease surveillance system with real-time analytic capabilities.**	**Mobile-based health information solutions developed with a focus on user-centred design can be successfully deployed at mass gatherings in resource-scarce settings to optimise care delivery by providing real-time access to field data.**
Nhavoto et al. (2017)	**Mozambique**	**Impact of mobile health treatment support intervention for HIV and tuberculosis in Mozambique.**	**Randomised controlled trial**	**The results suggest that SMS technology for HIV and TB should be used to transmit reminders for appointments, medications, motivational texts, and health education to increase retention in care.**
Atnafu et al. (2017)	**Ethiopia**	**To assess the role of mHealth intervention on maternal and child health service delivery**	**Randomised controlled trial**	**The study showed that SMS-based mobile telephone intervention could indeed improve the effectiveness of frontline HEWs in rural Ethiopia.**

Marufu & Maboe (2017)	**Zimbabwe**	**Determining the use of mHealth and identifying and describing the opportunities and the challenges faced by the medical doctors in using mHealth.**	**Quantitative, descriptive, cross-sectional and analytical design.**	**The majority of the respondents (83.3%) believed that mHealth presented opportunities to improve healthcare delivery.**
Tchao et al. (2017)	**Ghana**	**Evaluating the existing telemedicine systems in Kumasi and exploring the potential of extending telemedicine coverage across the entire city using WiMAX**	**Network architecture design and simulations**	**The study demonstrated the potential of WiMAX technology to enhance healthcare delivery.**

Kenny et al. (2017)	**Nigeria**	**To investigate primary healthcare workers' attitude to mHealth adoption**	**Qualitative exploratory study**	**Findings indicate that PHC workers expressed positive perceptions regarding the relevance and benefits associated with the IMPACT app.**
Peprah et al. (2019)	**Ghana**	**To provide a snapshot and baseline evidence on knowledge, attitude and use of mHealth among university students in Ghana.**	**Cross-sectional survey**	**Students had a generally positive attitude towards mHealth technology and recognized its potential benefits for healthcare, there were gaps in their knowledge and practical usage of these technologies.**
Nichols et al. (2017)	**Ghana**	**To assess the capacity for mHealth interventions and explore task-shifting strategies to improve hypertension management among Ghanaian stroke survivors.**	**Mixed-methods**	**Leveraging mHealth technologies could significantly enhance hypertension management by facilitating communication and follow-up care.**

Moodley et al. (2017)	**South Africa**	**To determine the feasibility of mobile health (mHealth) phone technology to improve management and follow-up of clients with cervical cancer precursor lesions.**	**Cross-sectional survey**	**Results indicated interest and potential for mHealth interventions in improving follow-up and management of clients with abnormal Pap smears.**
Nelissen et al. (2018)	**Nigeria**	**Assessing the impact of employing mHealth pharmacy-based interventions for hypertension care**	**Mixed methods feasibility study.**	**Most patients were satisfied, and their mean blood pressure significantly reduced.**

Pérez-Sánchez et al. (2018)	**Mexico**	**To evaluate the impact of short text messages for an HIV mobile-health intervention to improve antiretroviral treatment adherence.**	**Cross-sectional study**	**These SMS messages improved ART adherence and healthcare appointment attendance.**
Ronen et al. (2018)	**Kenya**	**To assess the impact of SMS messaging to improve ART adherence.**	**Randomised controlled trial**	**Findings show there may be interest in overt HIV-related information by SMS when risk of status disclosure is low.**
Stankievich et al. (2018)	**Argentina**	**Evaluation of mobile communication devices as a tool to improve adherence to antiretroviral treatment in HIV-infected children and young adults.**	**Prospective study**	**The use of mobile devices and social networks is a valid tool to improve ART adherence in HIV+ pediatric and young adults.**

Shabut et al. (2018)	**Malaysia**	**An investigation into the development of an intelligent mobile-enabled expert system to perform an automatic detection of tuberculosis (TB) disease in real-time.**	**An intelligent mobile-enabled expert system for tuberculosis disease diagnosis in real time.**	**The proposed intelligent system with real time processing capabilities and data portability can provide the prediction without any opto-mechanical attachment.**
Sonagli et al. (2018)	**Brazil**	**Evaluating the use of telemedicine to maintain breast cancer follow-up and surveillance during the COVID-19 pandemic.**	**Retrospective study**	**Telemedicine is a feasible alternative to reduce personal outpatient appointments for cancer follow-up and breast cancer screening during the COVID-19 pandemic.**
Harding et al. (2018)	**Ethiopia**	**Evaluation of a mHealth intervention designed to support Ethiopia's eHealth strategy.**	**Implementation research study.**	**The implementation of the mHealth model significantly improved access to healthcare services, particularly in maternal and child health, in rural and resource-limited settings.**

Najjar and Shaer (2018)	**Palestine**	**To assess the causes for lack of adherence to the appointment system at UNRWA centres.**	**Descriptive cross-sectional study.**	**The text messaging reminder is a successful way of improving patient's adherence to appointments in UNRWA clinics for non-communicable diseases**
Tobe et al. (2018)	**Bangladesh**	**Evaluation of a mobile-health tool to improve maternal and neonatal health care in Bangladesh.**	**Cluster randomized trial**	**The intervention incorporating the home-based health records with the mobile health network can improve health seeking behaviors of pregnant women living in rural Bangladesh, for better maternal and neonatal health outcomes**
van der Kop et al. (2018)	**Kenya**	**To determine whether a text-messaging intervention improved retention during the first year of HIV care.**	**Open-label, randomised parallel-group study**	**The intervention might have a modest role in improving self-perceived health-related quality of life in individuals in HIV care in similar settings.**

Medhanyie et al. (2018)	**Ethiopia**	**Evaluating health workers' experiences, barriers, preferences and motivating factors in using mHealth forms**	**Qualitative research study**	**Both HEWs and midwives found the electronic forms on smartphones useful for their day-to-day maternal health care services delivery**
Alvis-Estrada et al. (2021)	**Guatemala**	**To develop and assess a mobile application designed to monitor health navigation services for people living with HIV.**	**Mixed-methods approach**	**The app effectively captured real-time data on the mode, content, and duration of health navigation services**
Elhadi et al. (2021)	**Libya**	**To assess the usability of telehealth services in Libya and to provide an overview of the current COVID-19 scenario.**	**Cross-sectional study**	**The study revealed high levels of usability and willingness to use the telemedicine system as an alternative modality to in-person consultations among the Libyan residents.**

Elhadi et al. (2021)	**Libya**	**To provide an overview of physicians' awareness, knowledge, attitude, and skill in using telehealth services.**	**Cross-sectional study**	**There is a need to train and support health care workers and initiate government programs that provide adequate and supportive health care services to patients in transitional countries.**
Alessi et al. (2021)	**Brazil**	**To assess the impact of teleintervention on mental health parameters in type 2 diabetes patients during the coronavirus disease 2019 (COVID-19) pandemic.**	**Randomised controlled trial**	**The study demonstrated that maintaining remote communication between healthcare professionals and individuals with type 2 diabetes during periods of social distancing and quarantine can help reduce the prevalence of mental health disorders and emotional distress related to diabetes.**

DeSilva et al. (2019)	**Vietnam**	**To evaluate the effectiveness of an mHealth intervention designed to improve medication adherence among adolescents living with HIV in Vietnam.**	**Randomised controlled trial**	**mHealth intervention significantly improved medication adherence among adolescents living with HIV in Vietnam.**
Perez-Noboa et al. (2021)	**Ecuador**	**A performance assessment of the teleconsultation apps used during the critical periods of the pandemic.**	**Survey model**	**A high percentage of physicians monitored their patients through different apps despite not being virtual-oriented, providing both public and private care from homes or wherever the attention was required.**

Perez-Sanchez et al. (2018)	**Mexico**	**To develop, validate, and test a series of short text messages tailored for an HIV mobile health intervention aimed at improving antiretroviral treatment adherence among patients in Mexico.**	**Mixed-methods approach**	**The designed text messages were well-received by participants and effectively improved their knowledge and motivation regarding adherence to antiretroviral therapy.**
Owusu et al. (2023)	**Ghana**	**To provide an extensive description of the digital systems currently employed to enhance Ghana's paper-based disease surveillance system in the context of its response to COVID-19.**	**Descriptive research design**	**The use of these digital systems significantly enhanced Ghana's disease surveillance capabilities, reducing the delays caused by paper-based reporting and enabling timely production of situational updates.**

Montenegro et al. (2021)	**Peru**	**To examine telemedicine's implementation in response to the pandemic and its impact on oncological care.**	**Descriptive research design**	**Telemedicine provided a critical solution for maintaining continuity of care for cancer patients in Peru, enabling consultations, follow-ups, and treatment monitoring while reducing the risk of COVID-19 transmission.**
Morgenstern-Kaplan et al. (2022)	**Mexico**	**To evaluate an app-based telemedicine program for primary care and specialist video consultations during the COVID-19 pandemic in Mexico.**	**Descriptive research design**	**The use of mobile applications and video consultation services can encourage patients to improve their health and prevent complications in the short and long terms.**
Mostafa and Hegazy (2022)	**Egypt**	**To evaluate the impact of teledermatology during COVID-19.**	**Cross-sectional observational study**	**Teledermatology was efficient in triaging and treatment, hence, decreasing risk of COVID-19 exposure.**

Escobar et al. (2022)	**Colombia**	**To identify an association in maternal and perinatal care quality indicators after implementing a model based on telehealth and education for patients with obstetric emergencies.**	**Descriptive ecological study**	**Implementing a model based on telehealth and education between secondary and tertiary care centers allowed the strengthening of the security of care in obstetric emergencies and had a positive effect on perinatal mortality.**
Berihun et al. (2020)	**Ethiopia**	**To estimate the proportion of the willingness of professionals in Bahir Dar city to use EMR and at identifying factors associated with this proportion.**	**Cross-sectional study**	**Enhancing health professionals' attitude and contextualizing EMR training in the healthcare curricula are highly recommended to scale up EMR use.**

Mahajan et al. (2020)	**India**	**To gather insights from healthcare professionals and patients about their experiences and perceptions of telemedicine during the pandemic.**	**Qualitative research design**	**The study found that telemedicine significantly improved access to healthcare services while minimising the risk of COVID-19 transmission.**
Shalash et al. (2020)	**Egypt**	**To investigate the perspective of healthcare providers and patients with Parkinson's disease regarding their experiences with virtual visits during the COVID-19 pandemic.**	**Cross-sectional survey method**	**The study found that virtual visits were effective in managing Parkinson's disease patients during the pandemic, allowing continuity of care while minimizing infection risk.**

Barron et al. (2016)	**South Africa**	**To evaluate the early impact of the MomConnect mHealth initiative on the supply side of maternal and child health (MCH) services in South Africa**	**Descriptive evaluation research method**	**The MomConnect initiative improved communication between healthcare providers and pregnant women, leading to better maternal and child health services.**
Si et al. (2020)	**China**	**To investigate whether the proposed model could manage patients with epilepsy (PWEs) during the coronavirus disease 2019 (COVID-19) outbreak.**	**Cros-sectional observation study**	**The study highlighted the need for enhanced telemedicine solutions and support systems to ensure continuity of care for epilepsy patients during public health emergencies.**

Helou et al. (2020)	**Lebanon**	**To understand how physicians adapted to the sudden need for telehealth and if their perception of telehealth changed due to their experience during the COVID-19 pandemic.**	**Exploratory sequential mixed methods approach.**	**There was a significant shift in the physicians' perceptions, indicating greater openness and willingness to adopt telehealth services.**
Ratchakit-Nedsuwan (2020)	**Thailand**	**To evaluate whether a budgeted mobile-based system called CARE-call can enhance medication adherence**	**Pilot study research**	**The mobile-based CARE-call system significantly improved treatment adherence among tuberculosis patients.**

Samadi et al. (2020)	**Iran**	**Impact of a hybrid telepractice approach to support parents of children with Autism Spectrum Disorder (ASD) during the COVID-19.**	**Feasibility study**	**Hybrid telepractice was feasible and beneficial for parents, providing them with essential support and resources during the lockdown.**
Danquah et al. (2019)	**Sierra Leone**	**To design and evaluate an electronic system for tracing contacts of Ebola cases**	**Proof-of-concept study research method**	**Mobile application effectively facilitated contact tracing and monitoring, demonstrating its potential to enhance public health responses during infectious disease outbreaks.**

Kumar et al. (2019)	**India**	**To assess the mobile phone usage patterns and the acceptability of mobile phone support during care and treatment in patients with tuberculosis.**	**Exploratory study**	**mHealth interventions should consider language, mode of communication, and preferred timing for communication to improve uptake**
Govender et al. (2019)	**Mozambique, South Africa, Zimbabwe**	**To test the effectiveness of a SMS intervention in reducing HIV risk behaviours and improving HIV testing behaviours.**	**Cluster randomised control trial**	**The results indicate that the general SMS intervention, which provide health promoting information, improved HIV testing rates in key and vulnerable populations in southern Africa.**
Lewis et al. (2019)	**Kenya**	**To determine the perspectives of potential FP users to inform design of SMS.**	**Focus group discussions (FGD) and in-depth interviews (IDI).**	**SMS has the potential to facilitate family planning education, counselling, and interaction with HCWs.**

Jonas et al. (2016)	**Congo**	**To evaluate the feasibility and diagnostic accuracy of a smartphone-based solution for administering the CRD test for preeclampsia in resource-limited settings.**	**Pilot study**	**Smartphone-based CRD test was both feasible and effective for diagnosing preeclampsia in low-resource environments.**
Olamoyegun et al. (2020)	**Nigeria**	**To investigate the role of mobile phone use in the management of diabetes among patients.**	**Cross-sectional survey**	**Mobile phone use can significantly enhance diabetes management among patients.**
Mugo et al. (2020)	**Kenya**	**To assess the effect of appointment reminders on attendance for repeat HIV testing.**	**Randomised controlled trial**	**This low-cost intervention could facilitate detection of acute HIV infections and uptake of recommended repeat testing.**

Hermans et al. (2017)	**Uganda**	**To test the effect of a short-message service (SMS) intervention on loss to follow-up (LFU)**	**Quasi-experimental study**	**An SMS reminder service did not show a clear effect on short-term risk of LFU in this study.**
Shenoy et al. (2020)	**India**	**To assess the feasibility of teleconsultation in rheumatology and evaluate patient responses to this mode of care delivery during the pandemic in India.**	**Cross--sectional survey design.**	**A significant majority of patients reported satisfaction with teleconsultation, highlighting its convenience and accessibility.**
Ibraheem and Akintola (2017)	**Nigeria**	**Evaluation of the acceptability of reminders for immunization appointment by mothers in Ilorin, Nigeria.**	**Cross-sectional study**	**Most mothers are willing to receive reminders on immunization appointments via their mobile phone.**

Roberts et al. (2015)	**Uganda**	**To evaluate the effectiveness of mobile phones as a tool for delivering maternal health education to women in rural eastern Uganda.**	**Pilot study**	**Mobile phones were an effective means of increasing access to maternal health education for women in rural areas.**
Lau et al. (2014)	**South Africa**	**To increase antenatal health knowledge and awareness by disseminating text messages about clinic procedures at antenatal visits, and how to be healthy during pregnancy.**	**Mixed methods research**	**Evidence from self-reported behaviour and the focus group suggests that text messages have the potential to motivate change in health-seeking behaviour.**

Sahu et al. (2020)	**India**	**To implement an e-consult for SUD management and measuring its acceptability among the health care providers (HCPs) in India.**	**Cross-sectional survey**	**There was a high level of acceptance for e-consultation among patients with substance use disorders.**
Leochico et al. (2021)	**Philippines**	**To explore the role of telerehabilitation in the training of rehabilitation medicine professionals during the COVID-19 pandemic in a developing country.**	**Qualitative approach**	**Telerehabilitation was effective in maintaining continuity of care and education during the pandemic.**

Hong et al. (2020)	**China**	**evaluate the implementation of telemedicine services in Western China during the COVID-19 pandemic.**	**Descriptive study**	**Telemedicine played a crucial role in providing continuous healthcare during the pandemic, especially in remote areas.**
Bootha and Booi (2016)	**South Africa**	**To explore the implementation of mHealth solutions in South Africa, focusing on the challenges and successes faced during the process.**	**Qualitative approach**	**The study identified several barriers to effective mHealth implementation, including infrastructural limitations, lack of training among healthcare providers, and issues related to user engagement.**

Senjam et al. (2021)	**India**	**To evaluate the effectiveness and challenges of tele-rehabilitation services provided to visually challenged students during the COVID-19 pandemic.**	**Mixed methods research**	**Tele-rehabilitation was beneficial in providing continued support and resources to visually challenged students during lockdowns**
Modi et al. (2019)	**India**	**To evaluate the effectiveness of the ImTeCHO mobile health intervention in improving the delivery of maternal, neonatal, and child healthcare services in tribal areas.**	**Open cluster-randomised trial**	**The study found that the use of ImTeCHO mobile- and web-based application as a job aid by government ASHAs and PHC staff improved coverage and quality of MNCH services in hard-to-reach areas.**

Panda et al. (2020)	**India**	**To evaluate the feasibility and effectiveness of teleconsultation for managing children with epilepsy during the COVID-19 pandemic in a resource-limited. country**	**Cross-sectional study**	**Teleconsultation was feasible and acceptable for managing pediatric epilepsy, with many families reporting satisfaction with the service.**

Hoagland et al. (2020)	**Brazil**	**To assess the effectiveness and feasibility of using telemedicine for delivering pre-exposure prophylaxis (PrEP) during the COVID-19 pandemic in a large HIV prevention service in Rio de Janeiro, Brazil**	**Mixed-methods approach**	**Telemedicine significantly facilitated access to PrEP services during the pandemic, allowing for continuity of care despite physical distancing measures.**
Tran et al. (2020)	**Madagascar**	**To assess the performance of smartphone-based digital images for the detection of cervical intraepithelial neoplasia grade 2 or worse (CIN2+).**	**Cross-sectional study**	**Smartphone-based digital images, with its high portability, have a great potential for the diagnosis of CIN2+ in low-resource context**

Urner et al. (2017)	**Madagascar**	**To evaluate the performances of digital smartphone-based visual inspection with acetic acid (D-VIA) and Lugol's iodine (D-VILI) for diagnosing cervical precancer and cancer**	**Prospective study design**	**Smartphone-based image for triage of HPV-positive women is more accurate for detecting CIN2+ lesions with D-VIA than D-VILI, although with a small loss of specificity.**
Chirambo et al. (2018)	**Malawi**	**To explore the perceptions of Health Surveillance Assistants (HSAs) in Malawi regarding the use of a mobile health (mHealth) intervention for Community Case Management (CCM)**	**Qualitative research**	**mHealth intervention was perceived as a valuable tool for improving community healthcare delivery, particularly in remote areas.**

Bickton et al. (2021)	**Malawi**	**To evaluate whether an improvised pulmonary telerehabilitation program could be effectively implemented and accepted by patients in a low-resource setting following COVID-19.**	**Mixed methods research**	**The telerehabilitation program was both feasible and well-received by participants, who reported improvements in their physical functioning and overall well-being.**
Wang et al. (2021)	**China**	**To investigate the implementation of online hospitals in China and identify the factors influencing the adoption of mobile medical services among patients.**	**Cross-sectional survey**	**Convenience, accessibility, and the perceived quality of care significantly influenced patients' willingness to adopt mobile medical services.**

Zhang et al. (2020)	**China**	**To assess the influences of daily disruptions related to the COVID-19 pandemic on individuals' mHealth emergency use.**	**Experience sampling method**	**The disruptions caused by COVID-19 significantly increased participants' intentions to use mHealth services, driven by factors such as heightened health concerns and the need for accessible healthcare solutions.**
Yahya et al. (2020)	**Nigeria**	**To examine ownership, frequency and pattern of use and problems encountered in the use of smartphones among all categories of doctors in hospitals in Kaduna, Nigeria.**	**Cross-sectional survey**	**Healthcare-related smartphone use among doctors in hospitals in Kaduna, Nigeria, was prevalent and perceived as beneficial for clinical practice.**

Table 2: Characteristics of Included Studies

2.7 Data Synthesis

An Excel spreadsheet was utilised to synthesise the observations from the collected data. The extracted data were then subjected to a comprehensive thematic synthesis, which entailed a meticulous coding process to uncover recurring, unique, and contradictory elements within the data. These codes were then utilised to distil and summarise the thematic content independently and organised into sub-themes (Thomas & Harden, 2008). This approach ensured a nuanced analysis, capturing the complexity and diversity of the data while facilitating the identification of patterns and contradictions across the studies.

3. Results

The reported applications and potential barriers of telemedicine and mHealth technologies in LMICs were systematically classified into seven overarching themes. The distribution of these identified themes, along with their respective subthemes, as observed across the articles reviewed in this study, is detailed in Table 3.

Table 3: Themes and Sub-Themes

Themes	Titles
Theme 1	**Telemedicine and mHealth Applications in LMICs**
Sub-Theme 1	**Medical Consultations for Non-Infectious Disease Screening**
Sub-Theme 2	**mHealth Applications for Infectious Disease Screening and Early Detection**
Sub-Theme 3	**mHealth Applications for Medication Adherence and Treatment Compliance**
Sub-Theme 4	**Disease Surveillance**
Sub-Theme 5	**Scheduled Visit Notifications**

Sub-Theme 6	**Enhancing Maternal and Child Health Outcomes**
Sub-Theme 7	**Enhancement of Communication Dynamics Between Healthcare Providers and Between Providers and Patients**
Theme 2	**Challenges and Barriers to the Effective Implementation of Telemedicine and mHealth Applications**
Sub-Theme 1	**Geographical Access and Internet Connectivity Barriers**
Sub-Theme 2	**Policy/Regulatory Barriers**
Sub-Theme 3	**Funding challenges**
Sub-Theme 4	**Limited Awareness**
Sub-Theme 5	**Limited Healthcare Workers' Competence**
Sub-Theme 6	**Inadequate Information and Communication Technology Infrastructure (ICT).**
Sub-Theme 7	**Quality of Care**
Theme 3	**Facilitators for Effective Implementation of Telemedicine and mHealth Applications.**
Sub-Theme 1	**Technological Facilitators**
Sub-Theme 2	**Regulatory Facilitators**
Sub-Theme 3	**Knowledge, Attitudes, and Perceptions of Stakeholders.**
Sub-Theme 4	**Performance of mHealth Applications for Disease Diagnosis.**

3.1 *Theme 1:* Telemedicine and mHealth Applications in LMICs

3.1.1 *Sub-Theme 1*: Medical Consultations for Non-Infectious Disease Screening

In low- and middle-income countries (LMICs), the increasing effectiveness of telemedicine and mobile health (mHealth) applications in accelerating medical diagnoses is well-documented. For example, Hoagland et al. (2020) provided 564 HIV-positive participants in Brazil with HIV self-testing kits, followed by telemedicine consultations to streamline access to pre-exposure prophylaxis (PrEP). Similarly, in a study conducted by Montenegro et al. (2021), telemedicine-based palliative care consultations were offered to 273 cancer patients in Peru. Morgenstern-Kaplan et al. (2022) also reported delivering nearly 2,500 free video consultations to 1,545 pediatric patients. In Egypt, Mostafa and Hegazy (2022) utilised email to conduct asynchronous teleconsultations with 62 patients suffering from dermatological conditions. Additionally, Shalash et al. (2020) performed virtual neurological assessments covering motor and non-motor functions for 19 patients diagnosed with Parkinson's disease.

Furthermore, research conducted in low- and middle-income countries (LMICs) underscores the significant role that mHealth applications have played in enhancing cancer screening efforts in rural populations (Erwin et al., 2019; Moodley et al., 2019). Additionally, one study further illustrated the effectiveness of mHealth technologies in the screening and management of cardiovascular conditions in remote communities (Raghu et al., 2015). In Brazil, similar platforms have been utilised to assist in diagnosing cases of chest pain (Farah et al., 2019). Furthermore, a survey from Nigeria highlighted the pivotal role of mHealth platforms used by frontline healthcare workers for diagnosing diseases and conducting differential diagnoses based on patient symptoms and clinical presentations (Yahya, 2019).

The findings illustrate that telemedicine and mHealth applications have significantly enhanced medical diagnosis and care in low- and middle-income countries (LMICs), with notable successes in HIV testing, palliative care, paediatric consultations, and various disease screenings, including cancer, cardiovascular conditions, and non-communicable diseases, across diverse and often remote settings.

3.1.2 *Sub-Theme 2*: mHealth Applications for Infectious Disease Screening and Early Detection

Research by Sutcliffe et al. (2017) highlights the potential of mobile health (mHealth) technologies and applications in facilitating the screening of infectious diseases such as COVID-19, Ebola, Severe Acute Respiratory Syndrome (SARS), and HIV in LMICs. Similarly, following the Ebola and Zika virus epidemics in West Africa, Danquah et al. (2019) conducted a study in Sierra Leone, illustrating the effectiveness of mHealth applications in promoting early screening and testing of infected patients. Additionally, a cluster randomised controlled trial by Govender et al. (2019) across South Africa, Zimbabwe, and Mozambique found that mHealth interventions significantly increased HIV testing rates among vulnerable populations in rural communities. In a similar study conducted in Malaysia, Shabut et al. (2018) highlighted that mHealth applications supported the real-time diagnosis and detection of tuberculosis (TB).

These results collectively demonstrate how telemedicine and mHealth technologies have been instrumental in advancing the screening, diagnosis, and management of infectious diseases, including COVID-19, Ebola, SARS, HIV, and tuberculosis, across LMICs, with notable successes in remote and resource-constrained settings.

3.1.3 *Sub-Theme 3:* mHealth Applications for Medication Adherence and Treatment Compliance

According to Eilu (2018), in Sub-Saharan Africa, poor treatment adherence and medication non-compliance contribute to increased mortality rates and the proliferation of multi-drug resistance, among other adverse outcomes. In a study conducted in Southern Brazil, Alessi et al. (2021) followed 91 participants with a prior diagnosis of type 2 diabetes through weekly phone consultations lasting 5–10 minutes each over 16 weeks. These participants, who could not access outpatient clinics due to COVID-19 restrictions, were supported through mHealth applications to ensure sustained medication adherence. Similarly, Montenegro et al. (2021) investigated telemedicine opportunities in managing oncology patients in Peru during the COVID-19 pandemic. The study, involving 273 participants, provided telemedicine-based follow-up visits to address patient questions and manage comorbidities, which resulted in improved patient outcomes.

In a study by Khonsari et al. (2015), the impact of automated SMS-based reminders on medication adherence was examined in patients discharged after acute coronary syndrome (ACS) in Malaysia. The findings revealed that mHealth interventions significantly enhanced adherence to cardiovascular disease medications and treatment regimens. Similarly, Menon et al. (2018) conducted a study in India which demonstrated that text message reminders from healthcare professionals improved medication adherence among patients with bipolar I disorder. Additionally, studies by Georgette et al. (2017), Menon et al. (2018), Pérez-Sánchez et al. (2018), Ronen et al. (2018), Stankievich et al. (2018), and DeSilva et al. (2019) in India, South Africa, Mexico, Argentina, Kenya, and Vietnam, respectively, further illustrated that mHealth reminders played a pivotal role in supporting healthcare workers to ensure adherence to antiretroviral therapy among HIV-infected patients.

The study by Kamal et al. (2015) in Pakistan demonstrated that customised SMS interventions significantly improved medication adherence and positively affected stroke risk factors, such as diastolic blood pressure, among stroke survivors with complex medication regimens residing in resource-limited areas. Similarly, research by Haberer et al. (2016) in Uganda and Nhavoto et al. (2017) in Mozambique revealed that the introduction of mHealth interventions in sub-Saharan Africa markedly enhanced medication adherence and compliance with antiretroviral therapy (ART).

Additionally, Ratchakit-Nedsuwan (2020) found that in Thailand, mHealth applications deployed by healthcare professionals were practical in assisting tuberculosis patients with treatment and medication adherence. In a related study, Hirsch-Moverman et al. (2017) reported that mHealth interventions for HIV and tuberculosis treatment support in Lesotho were characterised by their low-tech, user-friendly nature, which was well-received by both patients and healthcare providers and led to increased adherence to treatment protocols. Additionally, a survey conducted in Nigeria by Nelissen et al. (2018) highlighted that mHealth interventions facilitated improved adherence to medication regimens among hypertensive patients.

The studies presented from these countries show that mHealth and telemedicine interventions, including SMS reminders, have significantly enhanced medication adherence and treatment outcomes across diverse contexts, ranging from cardiovascular

disease and diabetes management to HIV, tuberculosis, and hypertension, particularly in LMICs.

3.1.4 *Sub-Theme 4:* Disease Surveillance

According to Eilu (2018), logistical, financial, and infrastructural constraints significantly hinder the effective surveillance of infectious and non-infectious disease outbreaks in LMICs. However, the introduction of telemedicine and mHealth interventions in these regions has markedly reduced the costs associated with disease surveillance and provided a more efficient means of conducting such activities (Eilu, 2018). Additionally, studies by Kamal et al. (2015) and Bobrow et al. (2016) suggest that mHealth interventions can potentially deliver lifesaving information to even the most remote and resource-limited settings in LMICs, significantly improving patient outcomes.

Similarly, Owusu et al. (2023) revealed that Ghana utilised a range of digital surveillance tools, including the Surveillance Outbreak Response Management and Analysis System (SORMAS), digital health declaration forms, ArcGIS Survey123, Talkwalker, Lightwave Health Information Management System (LHIMS), and the District Health Information Management System (DHIMS). These tools significantly enhanced Ghana's capacity to respond successfully to the COVID-19 pandemic.

Furthermore, a study conducted in Tanzania by Mtema et al. (2016) demonstrated that an intersectoral mobile-phone-based system, developed and implemented for rabies surveillance across southern Tanzania, facilitated near real-time reporting of animal bites and human and animal vaccine usage. This system, involving over 300 frontline health and veterinary workers, generated nearly 30,000 reports across a catchment area of 150,000 km^2, serving over 10 million inhabitants. The system improved data quality, timeliness, and completeness while significantly reducing operational costs. Similarly, studies by Toda et al. (2016) in Kenya and Kazi et al. (2017) in India highlighted that user-centred mHealth technologies significantly enhanced surveillance efforts and healthcare delivery in resource-limited settings when deployed for disease surveillance.

3.1.5 *Sub-Theme 5:* Scheduled Visit Notifications

Hirsch-Moverman et al. (2017) highlighted the effective use of telemedicine and mHealth applications in promoting appointment adherence among patients in LMICs. In Nigeria, a study by Ibraheem and Akintola (2017) demonstrated that sending text message

reminders to postpartum women significantly increased postnatal care visits. Similarly, research in Lesotho (Hirsch-Moverman et al., 2017) and Zimbabwe (Marufu & Maboe, 2017) found that mHealth interventions reduced missed clinic appointments, improving patient outcomes. In Palestine, Najjar and Shaer (2018) reported that the United Nations Relief and Works Agency for Palestine Refugees in the Near East (UNRWA) implemented a mobile phone text messaging system to manage the rising number of patients with non-communicable diseases. This intervention aimed to ensure optimal care delivery with reduced waiting times and successfully promoted adherence to clinic appointments, particularly among patients with non-communicable diseases.

In Mozambique, Nhavoto et al. (2017) demonstrated that mHealth applications effectively supported HIV and TB patients by reducing missed medical appointments, thereby improving healthcare delivery quality. Similarly, Moodley et al. (2019) found that in South Africa, cancer patients with cervical cancer precursor lesions expressed a strong preference for receiving appointment reminders via mHealth platforms to enhance adherence to clinical appointments. Additionally, a study by Smith et al. (2015) in India indicated that mHealth reminders helped cardiovascular patients maintain clinical appointment schedules. In Guatemala, Alvis-Estrada et al. (2021) revealed that HIV patients were willing to use mobile phones for clinic appointment reminders to support adherence to antiretroviral therapy (ART). In Argentina, Cormick et al. (2015) reported high acceptance of SMS-based appointment reminders, particularly for postpartum women with Chagas disease in Tucumán, to confirm home visits. Furthermore, Mugo et al. (2016) found in Kenya that mHealth tools, including SMS and phone calls, significantly boosted HIV testing uptake by improving appointment attendance rates among patients.

3.1.6 Enhancing Maternal and Child Health Outcomes

Studies by Barron et al. (2016) and Escobar et al. (2022) in two LMICs (South Africa and Columbia) have demonstrated that mHealth interventions are a practical and effective solution for improving maternal, neonatal, and child health services. Similarly, Kumar et al. (2019) found that mHealth applications can significantly strengthen the provision of postnatal care (PNC) to mothers and neonates in rural areas, promoting higher healthcare standards. Furthermore, research by Lund et al. (2014) and Lau et al. (2014) indicated that mHealth technologies have the potential to enhance both antenatal and postnatal

care services in LMICs, particularly by positively influencing the behaviour of pregnant women and new mothers during the postnatal period.

Atnafu et al. (2017) in Ethiopia reported that mHealth interventions have significantly increased antenatal care visits among expectant mothers and the proportion of deliveries attended by skilled healthcare workers. Similarly, studies by Tobe et al. (2018) in Bangladesh and Modi et al. (2019) in India demonstrated that mHealth applications enhanced the quality of maternal, neonatal, and child health services, particularly in underserved, hard-to-reach communities. In Nigeria, McNabb et al. (2015) found that mHealth tools contributed to behavioural changes among pregnant women, thereby improving the quality of maternal and child healthcare delivered by frontline community health workers in Northern Nigeria.

3.1.7 *Sub-Theme 7:* Enhancement of Communication Dynamics Between Healthcare Providers and Between Providers and Patients

Numerous studies have highlighted the utility of telemedicine and mHealth applications in facilitating health information exchange among healthcare providers, conducting specialist consultations, and obtaining second opinions (Nhavoto et al., 2017; Zamberg et al., 2020). These technologies have also notably enhanced the relationship between healthcare practitioners and their patients. For instance, during the COVID-19 pandemic, Hong et al. (2020) reported that specialists and consultants in Western China remotely assessed patients with the assistance of local primary healthcare providers using remote Computed Tomography (CT) devices, allowing for the synchronous exchange of health information, medical records, images, and laboratory results. Similarly, Sahu et al. (2020) examined 68 participants in India receiving treatment for Substance and Alcohol Use Disorder (SAUD) who were unable to access healthcare facilities due to the COVID-19 lockdown. Despite this, care continued through asynchronous email communication between primary healthcare practitioners and psychiatrists, ensuring uninterrupted patient support.

Furthermore, Kumar et al. (2019) highlighted that in low- and middle-income countries (LMICs), regular communication via mHealth between healthcare professionals and patients has enhanced the quality of treatment support and strengthened patient-clinician relationships. Their study emphasised the utility of mHealth applications for

effective communication with tuberculosis patients during care and treatment. Similarly, a survey by Olamoyegun et al. (2020) in Nigeria demonstrated that mHealth applications could offer cost-effective solutions to overcoming communication barriers between diabetic patients and their healthcare providers, particularly in rural clinics. Additionally, in Malawi, Chirambo et al. (2018) found that the Supporting LIFE electronic CCM Application (SL eCCM App) significantly improved the accessibility of scientific and medical information to physicians, facilitating better communication with patients and fostering networking among physicians.

3.2 *Theme 2:* Challenges and Barriers to the Effective Implementation of Telemedicine and mHealth Applications

According to the World Health Organization (WHO, 2016), healthcare stakeholders' adoption of technological interventions in low-resource countries is impeded by a range of barriers and challenges. The reviewed studies consistently identified obstacles to implementing telemedicine and mHealth applications across LMICs. These challenges include geographical access and internet connectivity issues, policy and regulatory barriers, funding constraints, limited competence among healthcare workers, insufficient awareness of mHealth services, inadequate information and communication technology (ICT) infrastructure, poor architecture and standardisation, as well as concerns related to the quality of care and access to healthcare.

3.2.1 *Sub-Theme 1:* Geographical Access and Internet Connectivity Barriers

The study by Medhanyie et al. (2015) identified geographical access as a critical barrier to implementing mHealth technologies and applications for disease screening and treatment support in resource-limited settings across LMICs. Similarly, research by Liu and Lin (2014) and Roberts et al. (2015) in Uganda highlighted that rural populations in many LMICs face significant challenges due to the need for long-distance travel, high transportation costs, and inadequate road infrastructure, which can hinder patients' ability to access healthcare and adversely impact their health conditions. Furthermore, Harding et al. (2018) noted that unreliable mobile network coverage, insufficient cellular signal, unstable internet services, and intermittent power supply in LMICs present substantial barriers to utilising mHealth services. The minimal bandwidth for internet

connectivity and the high costs associated with internet access exacerbate these challenges, as many individuals in these regions cannot afford the necessary services.

3.2.2 *Sub-Theme 2:* Policy/Regulatory Barriers

In several LMICs, policy regulations significantly impede the development, implementation, and accessibility of telemedicine and mHealth technologies. Three studies (Hong et al., 2020; Shenoy et al., 2020; Perez-Noboa et al., 2021) identified the absence or inadequacy of policy frameworks as a significant barrier to adopting telemedicine strategies in these regions. Additionally, one study (Mahajan et al., 2020) highlighted confidentiality and privacy concerns as critical obstacles to telemedicine adoption in LMICs. Furthermore, two studies (Elhadi et al., 2021; Mahajan et al., 2020) noted that issues related to liability and unclear medicolegal standards significantly limit the utilisation of telemedicine in low-resource settings.

Furthermore, Hermans et al. (2017) emphasised that concerns about data breaches are prevalent in LMICs, where mobile phones are often shared among family members. They also noted that inadequate policy regulations and guidelines regarding data security and privacy can deter patients from using mHealth services. Moreover, Tchao et al. (2017) found that in Ghana and similar LMICs, the absence of a robust legal framework for health data transfer, storage, access control, and medical liability poses a significant challenge to the effective implementation of mHealth interventions.

3.2.3 *Sub-Theme 3:* Funding Challenges

Two studies identified the high costs associated with implementing telemedicine services in LMICs as a significant barrier (Leochico et al., 2021; Perez-Noboa et al., 2021). Similarly, van der Kop et al. (2018), in their research conducted in Kenya, found that the costs of designing, developing, and maintaining ICT infrastructure often exceed the budgetary allocations for health sectors in many LMICs. Brinkel et al. (2017) further emphasised that health facilities in these regions struggle to collaborate with government agencies and the private sector to mobilise adequate resources for mHealth, hindering its implementation. Additionally, when mHealth service costs are unaffordable, particularly for patients in remote areas, access to these services becomes limited.

3.2.4 *Sub-Theme 4:* Limited Awareness

Si et al. (2020) identified digital illiteracy, particularly among the elderly, as a major barrier to telemedicine implementation in LMICs, as many individuals lack the necessary technical skills to use these technologies effectively. In a similar vein, Botha and Booi (2016) noted that limited awareness among stakeholders about the benefits of mHealth is a critical impediment to its successful implementation. This lack of awareness affects the accessibility and utilisation of mHealth services, as many individuals in low-resource areas remain unaware of how mHealth can support healthcare delivery and improve health outcomes.

3.2.5 *Sub-Theme 5:* Limited Healthcare Workers' Competence

Three studies (2020; Shalash et al., 2020; Leochico et al., 2021; Senjam et al., 2021) indicated that the shortage of adequately qualified healthcare professionals represents a significant barrier to the successful implementation and utilisation of telemedicine services in LMICs. Furthermore, two studies (Sahu et al., 2020; Elhadi et al., 2021) identified healthcare providers' reluctance and willingness to adopt telemedicine technologies as another critical challenge in these regions, impeding the effective deployment and usage of these services. Similarly, a study by Nhavoto et al. (2017) in Mozambique emphasised that the scarcity of ICT-trained health professionals in LMICs hinders the operation of mHealth interventions, thereby limiting efforts to support universal health coverage in these contexts and negatively affecting the adoption and utilisation of telemedicine solutions.

3.2.6 *Sub-Theme 6:* Inadequate Information and Communication Technology Infrastructure (ICT)

Four studies (Hong et al., 2020; Bickton et al., 2021; Perez-Noboa et al., 2021; Elhadi et al., 2021) identified inadequate infrastructure and equipment as critical barriers to the adoption of telemedicine services in LMICs. Additionally, three studies (2020; Shalash et al., 2020; Leochico et al., 2021; Senjam et al., 2021) emphasised the lack of technical support as a critical obstacle to effectively implementing telemedicine solutions in these regions. Furthermore, three studies (Shalash et al., 2020; Iyengar et al., 2021; Sonagli et al., 2021) highlighted that poor or slow internet connectivity and technological difficulties during telemedicine consultations pose significant challenges to the implementation and utilisation of these services in LMICs. Similarly, in their study in Ghana, Tchao et al. (2017)

revealed that the poor ICT infrastructure in LMICs poses a substantial challenge to the successful implementation of mHealth, particularly in resource-limited settings, adversely affecting patients' health outcomes.

3.2.7 *Sub-Theme 7:* Quality of Care

Five studies (Hong et al., 2020; Mahajan et al., 2020; Sahu et al., 2020; Elhadi et al., 2021; Perez-Noboa et al., 2021) highlighted that the inability to conduct physical examinations, administer treatments, collect samples, or perform laboratory tests in telemedicine could lead to potential misdiagnosis and lower patient satisfaction in LMICs. Additionally, one study (Wang et al., 2021) reported communication challenges in telemedicine that led to patient misunderstandings, including incorrect medication usage, thereby negatively affecting patient uptake of services. Two studies (Shalash et al., 2020; Montenegro et al., 2021) noted that the low quality of uploaded photos and videos could impair the quality of care. Furthermore, four studies (Hong et al., 2020; Si et al., 2020; Zhang et al., 2020; Sonagli et al., 2021) revealed that the absence of face-to-face interactions between healthcare providers and patients in LMICs can weaken patient-provider relationships, prolong telemedicine consultations, and ultimately affect the quality of care delivered.

3.3 *Theme 3:* Facilitators for Effective Implementation of Telemedicine and mHealth Applications

Several crucial facilitators were identified for successfully implementing telemedicine and mHealth applications in LMICs to support disease screening and treatment.

3.3.1 *Sub-Theme 1:* Technological Facilitators

Infrastructure availability is pivotal in supporting telemedicine and mHealth applications in low- and middle-income countries (LMICs). Notably, four studies (Helou et al., 2020; Hoagland et al., 2020; Panda et al., 2020; Samadi et al., 2020) emphasised the significance of broadband cellular networks, user-friendly mobile applications, and broader internet access as critical facilitators for successful implementation.

3.3.2 *Sub-Theme 2:* Regulatory Facilitators

Two of the studies reviewed (Helou et al., 2020; Sahu et al., 2020) highlighted that certain LMICs responded to COVID-19-related care limitations by enacting new legislation and regulations. These measures aimed to enable, facilitate, and sometimes regulate telemedicine and mHealth applications as viable alternatives for healthcare provision.

3.3.3 *Sub-Theme 3:* Knowledge, Attitudes, and Perceptions of Stakeholders

This review identified stakeholders' knowledge, attitudes, and perceptions as pivotal facilitators in the successful implementation of telemedicine and mHealth applications in low- and middle-income countries (LMICs), which are essential for ensuring quality healthcare delivery. Catalani et al. (2014) found that healthcare professionals in an LMIC perceived mHealth interventions as enhancing both accuracy and efficiency in service provision. Similarly, Kenny et al. (2017) demonstrated that primary healthcare workers in Nigeria exhibited positive attitudes toward mHealth adoption, which facilitated its integration in low-resource settings and improved healthcare delivery across sub-Saharan Africa.

A study conducted in Ghana by Peprah et al. (2019) found that enhanced knowledge among healthcare stakeholders regarding the use of mHealth interventions significantly facilitates their adoption in low- and middle-income countries (LMICs). Similarly, Nichols et al. (2017) revealed that patient confidence in the privacy and security of their medical information positively influences the uptake of mHealth applications. In Mozambique, Nhavoto et al. (2017) demonstrated that both healthcare workers' and patients' proficiency with mHealth technologies facilitates adoption, thus supporting healthcare delivery in resource-limited settings. Atnafu et al. (2017) further observed that health extension workers in Ethiopia, equipped with substantial knowledge and a positive attitude towards mHealth, promoted its use in maternal health services. Moreover, Berihun et al. (2020) reported that the willingness to adopt electronic medical record (EMR) systems in Ethiopian healthcare facilities enhanced the implementation of mHealth applications, supporting patient treatment and management in LMICs.

Furthermore, studies conducted in Lagos and Kenya demonstrated that healthcare workers and patients perceived mHealth interventions as comfortable and convenient tools for supporting healthcare delivery (Nelissen et al., 2018; Lewis et al., 2019).

3.3.4 *Sub-Theme 4:* Performance of mHealth Applications for Disease Diagnosis

Research by Jonas et al. (2016) in Congo suggested that smartphone-based image analysis, combined with molecular-specific disease features, offers a cost-effective mHealth solution with the potential to address critical gaps in healthcare access, particularly for diagnosing preeclampsia in resource-poor settings. The study highlighted that the successful implementation of this mHealth tool facilitated its adoption in such low-resource environments. Similarly, studies in rural Ghana and Côte d'Ivoire demonstrated the effective use of mHealth devices in diagnosing *Schistosoma mansoni*, *Schistosoma haematobium*, and other intestinal protozoa infections, enabling healthcare workers to deliver quality services (Ephraim et al., 2015; Coulibaly et al., 2016). Furthermore, in Botswana and Madagascar, studies have shown that the accurate screening of cervical cancer and Human Papillomavirus-positive conditions using mHealth devices significantly enhances their utilisation in low-resource settings (Urner et al., 2017; Tran et al., 2018).

4. Discussion

The review provides a comprehensive literature analysis concerning the benefits of telemedicine and mHealth applications, highlighting the key facilitators and barriers to their adoption in low- and middle-income countries (LMICs). The studies demonstrate that telemedicine and mHealth technologies have notably enhanced healthcare diagnostics in LMICs, with successful applications across contexts such as HIV testing, cancer palliative care, and pediatric consultations. These technologies have expanded access to essential health services in remote regions, facilitating screening for infectious diseases like COVID-19, Ebola, and HIV. Noteworthy implementations in Sierra Leone and South Africa have shown increased testing rates and early detection, which are crucial for controlling disease outbreaks. This aligns with Su et al. (2024), who demonstrated that telediagnosis platforms enable the seamless remote transmission of medical records, functioning identically across geographic locations. Similarly, Stoltzfus et al. (2023) found that telemedicine provides several advantages over in-person care, including reduced travel expenses, shorter waiting times, lower risk of disease transmission, faster consultations, and enhanced convenience for patients and healthcare providers. Osei and

Mashamba-Thompson (2021) further suggest that the growing penetration of mobile phones in LMICs positions mHealth services to reach broader populations, especially in resource-limited settings, thereby improving diagnostic care. The findings, thus, imply that telemedicine and mHealth technologies significantly enhance healthcare diagnostics in LMICs, expanding access to essential services, improving early disease detection, and offering numerous advantages such as reduced costs and increased convenience, particularly in resource-limited and remote settings.

Furthermore, the review highlights that telemedicine and mHealth interventions, such as SMS reminders, have been effective in boosting medication adherence in conditions like diabetes, cardiovascular diseases, and HIV, mitigating poor compliance and adverse health outcomes. Leiz et al. (2022) support this, noting that telemedicine and mHealth can supplement standard care interventions in underserved areas, improving adherence among patients with affective disorders. Additionally, the review underscores that telemedicine and mHealth have optimised disease surveillance, making it more efficient and cost-effective. Studies from Ghana and Tanzania reveal that these technologies have enhanced real-time reporting and data quality, which is critical for timely public health responses. These findings are consistent with research by Keeys et al. (2014), Sarkar et al. (2018), and Shokri et al. (2023), which show that telepharmacy increased the accuracy and documentation of patients' medication data, improving prescription error detection and correction. This implies that telemedicine and mHealth interventions significantly improve medication adherence and disease surveillance in low-resource settings, enhancing patient outcomes and public health response efficiency through real-time reporting and data accuracy.

The review also found that the widespread use of telemedicine and mHealth applications in LMICs has significantly improved patient adherence to scheduled visits, enhancing health outcomes. Successful implementations in Nigeria and Zimbabwe highlight the potential for more effective healthcare delivery. Additionally, mHealth interventions have been instrumental in advancing maternal and child health, with studies indicating increased antenatal visits and improved health behaviours among mothers in underserved regions. This supports the findings of Haleem et al. (2021), which demonstrate that telemedicine reduces both time and costs for patients and providers, streamlining healthcare workflows and improving post-discharge monitoring. Likewise,

Vudathaneni et al. (2024) provide strong evidence of telemedicine's positive impact on healthcare, reporting significant patient outcome improvements, substantial cost savings, and increased satisfaction levels. The findings, therefore, suggest that the effective implementation of telemedicine and mHealth applications in LMICs not only enhances patient adherence to healthcare schedules and improves health outcomes, particularly in maternal and child health, but also streamlines healthcare delivery, reduces costs, and increases overall patient satisfaction.

Despite the growing acceptance and utilisation of telemedicine and mHealth services, the findings from this review denote substantial barriers to their successful implementation in low- and middle-income countries (LMICs). Chief among these is the limitation of geographical access, particularly in rural regions where long travel distances, exorbitant costs, and inadequate infrastructure severely impede healthcare access. This aligns with Kiberu et al. (2017), who demonstrated that unreliable internet connectivity, insufficient bandwidth, and expensive services in LMICs significantly hinder the use of telemedicine. Van Olmen et al. (2020) also noted that the diversity of network providers and the fluctuating telecom landscape further complicates the selection of optimal data management platforms, creating substantial barriers in the highly commercialised telecom sectors of many LMICs. Moreover, the inadequate information and communication technology (ICT) infrastructure, compounded by slow internet connections, diminished the effectiveness of telemedicine services. Supporting this, Clifford et al. (2016), Mitchell-Gillespie et al. (2020), and Swartz et al. (2021) highlighted that the complexity of telemedicine technologies and limited network infrastructure constitute significant impediments to the feasibility of eHealth solutions. This implies that substantial barriers—mainly geographical access limitations, unreliable internet connectivity, and inadequate ICT infrastructure—hinder the effective implementation of telemedicine and mHealth applications in LMICs.

Further compounding these barriers are policy and regulatory challenges, particularly the absence of robust frameworks for data security and legal governance. This observation mirrors findings from Saigi et al. (2016) and Archer et al. (2021), which demonstrated that legal and ethical concerns pose substantial obstacles to telemedicine implementation in low-resource settings. Additionally, stable funding remains a critical issue, with the study by Chirambo et al. (2019) in Malawi emphasising the lack of

sustainable financial resources as a critical barrier. This corresponds with the review's finding that costs associated with implementing and maintaining telemedicine infrastructure often surpass available budgets in LMICs. Archer et al. (2021) also noted that the high initial costs of developing and deploying eHealth technologies further hinder their adoption. Limited awareness among service users and healthcare personnel regarding the benefits of telemedicine and mHealth services poses another significant barrier. The review identifies digital illiteracy and a shortage of ICT-skilled healthcare professionals as significant obstacles, with previous literature supporting this, noting that users' negative attitudes, fears, and limited knowledge of new technologies hamper the long-term sustainability of eHealth solutions (Safi et al., 2018; Herrera et al., 2022). Scholars such as Hassibian & Hassibian (2016), Zayyad & Toycan (2018), and Mitchell-Gillespie et al. (2020) further emphasise that the scarcity of technical experts with relevant skills and training is a critical limitation, as many health professionals lack the information technology proficiency required to use telemedicine and mHealth services in LMICs effectively. This indicates that policy and regulatory challenges, coupled with inadequate funding, limited awareness of telemedicine benefits, and a shortage of skilled professionals, significantly impede the implementation and sustainability of telemedicine and mHealth services in low- and middle-income countries (LMICs).

Despite the barriers to implementing and utilising telemedicine and mHealth applications in LMICs, this review highlighted several key enablers that facilitate their successful adoption. Technological facilitators, such as the widespread availability of broadband networks, user-friendly mobile applications, and enhanced internet access, were identified as pivotal in advancing telemedicine and mHealth services across LMICs. In alignment with this, other studies have demonstrated that improving technological infrastructure is instrumental in boosting telemedicine adoption. This leads to increased usage of video teleconferencing, mobile consultations, and greater convenience, reducing patient waiting times for specialist consultations and outpatient services, as well as saving time for healthcare providers and patients (Kumar et al., 2019; Appireddy et al., 2020; Kavadichanda et al., 2021). This suggests that enhancing technological infrastructure is crucial for increasing the adoption and effectiveness of telemedicine and mHealth services in LMICs.

Pandya et al. (2022) noted that, following the onset of COVID-19, many countries eased telemedicine regulations, allowing physicians in good standing to treat patients via telemedicine, even in regions where they lacked medical licenses. This finding aligns with the current study's observation that regulatory facilitators emerged during the COVID-19 pandemic, as some LMICs enacted supportive legislation to promote telemedicine use. Similarly, Yen et al. (2023) found that state insurance policies strongly influenced telehealth utilisation. Their study revealed that among privately insured patients, telehealth usage rates were 14% to 18% lower in states with coverage parity alone or ambiguous parity policies compared to states with both coverage and payment parity.

Stakeholder knowledge, attitudes, and perceptions were crucial in fostering telemedicine and mHealth adoption. This review demonstrated that healthcare workers in several LMICs, such as Nigeria and Mozambique, exhibited positive attitudes and competence with mHealth technologies, significantly contributing to their adoption. Shardha et al. (2024) similarly found in India that healthcare professionals' awareness of telecommunication technology and its appropriate application in healthcare enhanced their attitudes and perceptions, thereby facilitating the adoption of telemedicine and mHealth solutions. Furthermore, this review's findings indicated that patient confidence in data security and healthcare workers' familiarity with telemedicine and mHealth technologies improved healthcare outcomes and broader adoption. These results are consistent with studies by Messinger et al. (2024) and Alhammad et al. (2024), which observed that patient awareness of the benefits and capabilities of mHealth services significantly increased their willingness to adopt these technologies. The findings suggest that enhancing stakeholder knowledge and attitudes, particularly among healthcare workers and patients, is essential for driving the adoption of telemedicine and mHealth technologies, ultimately leading to improved healthcare outcomes in LMICs.

5. Limitations

While this review advances the existing literature by identifying recent facilitators and barriers to telemedicine systems in LMICs, several limitations should be acknowledged. First, despite employing a robust research strategy, the possibility remains that not all relevant studies were captured, particularly as some journals from developing countries

may not be indexed in the central databases. Secondly, excluding peer-reviewed journal articles to enhance the review's credibility may have inadvertently excluded valuable insights from grey literature or technology-focused publications. Critical sources of data on the challenges and enablers of telemedicine and mHealth implementation may be found in grey literature, which remains inaccessible either because it was not available on the consulted platforms or not catalogued in the databases used.

6. Recommendations

This systematic review emphasises the rapid advancement of telemedicine and mobile health (mHealth) applications, showcasing their potential to revolutionise healthcare in low- and middle-income countries. Despite their promise, several significant barriers continue to impede their effective implementation. To fully realise the benefits of these technologies, several vital actions must be taken.

Strengthening technological infrastructure is critical, and to achieve this, governments and stakeholders in LMICs should prioritise investments in reliable internet access, broadband networks, and information and communication technology (ICT) infrastructure. Improving these areas will enable broader adoption of telemedicine and mHealth services, particularly in rural regions where access to healthcare is often limited, as highlighted in this review. Public-private partnerships can play a pivotal role in addressing infrastructure gaps, helping to mitigate issues like unreliable connectivity and limited bandwidth (Joudyian et al., 2021).

Alongside infrastructure improvements, it is essential to enhance the digital literacy of healthcare providers. Targeted training programs that equip healthcare professionals with the technical skills and knowledge needed to use telemedicine and mHealth platforms will greatly improve their effectiveness. This can be achieved through workshops, certification programs, and ongoing professional development. Improving digital literacy among healthcare workers and patients will further increase the effective use of these technologies and lead to better health outcomes in LMICs (Fitzpatrick, 2023).

Moreover, the development of comprehensive policy and regulatory frameworks is vital. Policymakers in LMICs must establish clear guidelines to address legal, ethical, and data security concerns surrounding telemedicine and mHealth. This includes clear regulations

on patient data privacy, cross-border consultations, and accountability for telemedicine services, ensuring compliance and clarifying the roles of all stakeholders involved (Parimbelli et al., 2018).

Sustainable funding models are another critical aspect of successful telemedicine and mHealth implementation. Governments and international health organisations must create mechanisms to support the long-term development and maintenance of telemedicine infrastructure. Funding sources for public health initiatives and private healthcare providers will help ensure the affordability and sustainability of these technologies in resource-limited settings (Chirambo et al., 2019).

Promoting public awareness and engagement is also crucial for increasing the adoption of telemedicine and mHealth. Educational campaigns highlighting these technologies' benefits can significantly boost their acceptance. Engaging communities through local media, social platforms, and healthcare professionals will foster a better understanding of how telemedicine and mHealth can improve health outcomes, leading to wider utilisation (Taylor et al., 2015).

Additionally, integrating telemedicine into national healthcare strategies is essential. Governments in LMICs should recognise telemedicine as a core component of their healthcare systems and emergency response plans. Incorporating telemedicine and mHealth applications into national health strategies will improve healthcare access, strengthen responses to disease outbreaks, and enhance maternal and child health services in LMICs.

7. Conclusion

This study highlights telemedicine and mHealth technologies' transformative role in improving healthcare access, diagnostics, and patient outcomes in low- and middle-income countries (LMICs). These technologies have already shown promise in expanding access to critical health services, especially in remote and underserved areas, improving early disease detection, maternal and child health, and medication adherence. However, significant challenges remain. Issues such as inadequate infrastructure, unreliable internet, limited digital skills, policy gaps, regulatory constraints, funding shortages, and

a lack of ICT-trained healthcare professionals continue to impede the broader adoption of these innovations.

This research is not without limitations. Notably, the exclusion of grey literature and certain tech-focused publications may have left out essential insights, and regional underrepresentation due to indexing limitations in major databases may have impacted the completeness of the findings.

To address these challenges, this review recommends that LMICs prioritise investment in technological infrastructure, improve digital literacy, and establish robust regulatory frameworks. Sustainable funding and heightened awareness are also critical to fully integrating telemedicine and mHealth into national healthcare systems, which can help bridge gaps in healthcare delivery and promote equitable access in low-resource environments.

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Supplementary File 1

(telehealth OR telemedicine OR "digital health" OR "remote care" OR "hospital-at-home" OR "digitalised healthcare" OR "digitalised medical care" OR "virtual healthcare" OR "virtual medical care" OR teleconsultation OR videoconferencing) AND ("least economically developed countries" OR "non-industrialised nations" OR "lower-middle-income countries" OR "global south" OR "developing countries" OR "underdeveloped nations" OR "third-world countries" OR "third-world nations")

Supplementary Files

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