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Determinants of Mobile Health Adoption in Maternal and Reproductive Healthcare in Developing Countries: A Review of Concepts, Theories, Service Modalities, and Contextual Factors

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Abstract
Mobile health (mHealth) has emerged as a promising avenue for extending maternal and reproductive healthcare to underserved populations in developing countries, yet adoption remains uneven and incompletely understood. This review synthesises the conceptual, technological, theoretical, and empirical literature on mHealth adoption with particular reference to maternal and reproductive health in sub-Saharan Africa and Nigeria. It clarifies the relationship between eHealth and mHealth and the electronic health literacy on which use depends; describes the principal service modalities, ranging from voice calls and short messaging to voice over internet protocol, video conferencing, and instant messaging applications; and examines two complementary frameworks, the Unified Theory of Acceptance and Use of Technology and the socio-ecological model, that together explain adoption as a product of individual, interpersonal, organisational, community, and policy level forces. The review then organises the empirical evidence on barriers and determinants into individual, household, and community categories, covering age, gender, education, marital status, religion, occupation, electronic health literacy, perceived privacy risk, household socioeconomic position and women's autonomy, place of residence, culture and ethnicity, income and poverty, and community infrastructure and cohesion. It concludes that the literature is dominated by provider-centred and developed-country studies, that holistic, multi-level analyses of patient adoption in developing settings are scarce, and that maternal and reproductive populations warrant dedicated, context-sensitive investigation grounded in both acceptance theory and socio-ecological reasoning.

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1. Introduction

Information and communications technology has penetrated nearly every field of human activity, including health, where it offers a route to addressing inadequate access and reducing the cost of care (Witten & Humphry, 2018; Balogun *et al*., 2020; Udenigwen *et al*., 2022) [108, 11, 100]. The unprecedented proliferation of mobile technologies, and the evolution of their capabilities to address healthcare priorities, has given rise to mobile health, or mHealth, as a distinct domain within electronic health (Moss *et al*., 2019) [64]. With mobile cellular netw, ks now reaching most of the global population and mobile broadband expanding rapidly (Ray *et al*., 2011; Wallis *et al*., 2017; Wesolowski *et al*., 2012) [82, 106, 107], mHealth has become an instrument for delivering accessible and inclusive care at feasible cost (Gagnon *et al*., 2016; WHO, 2017; Laing *et al*., 2018) [31, 110, 51].

In low- and middle-income settings, mHealth is particularly attractive for maternal and reproductive health, where distance, cost, and the spatial distribution of facilities constrain timely access (Ajaegbu, 2013; Buor, 2003; Dahab & Sakellariou, 2020) [3, 20, 23]. Maternal and perinatal mortality remain high in parts of sub-Saharan Africa, and the timely detection and escalation of complications during pregnancy and childbirth depend on continuity of contact between women and providers that physical visits alone struggle to maintain. Nevertheless, adoption of mHealth remains modest and unevenly distributed, and a substantial literature has sought to explain why (Marufu & Maboe, 2017; Kruse *et al*., 2019; Udenigwen *et al*., 2022) [58, 50, 100].

This review synthesises that literature in five parts. It first clarifies the concepts of eHealth and mHealth, the importance and functional applications of mHealth, the trajectory of mobile application development, and the engagement of patients and professionals. It then describes the principal service modalities. Third, it sets out the two theoretical frameworks most widely used to explain adoption. Fourth, it organises the empirical evidence on barriers and determinants into individual, household, and community categories. Fifth, it considers maternal and reproductive applications in sub-Saharan Africa and Nigeria, before drawing out a synthesis of research gaps. The aim is to provide an integrated account that situates patient adoption within both acceptance theory and the wider social ecology of health.

The contribution of the review is integrative rather than merely descriptive. Existing treatments of mHealth adoption tend to privilege either the technology-acceptance tradition, with its focus on individual perceptions, or the social-determinants tradition, with its focus on structural and contextual forces, but rarely combine the two. By reading the evidence through both the Unified Theory of Acceptance and Use of Technology and the socio-ecological model, this review seeks to show how individual intentions and multi-level conditions jointly shape whether reproductive women take up mHealth, and to identify where the literature is thin, particularly on patient-side adoption, on the holistic interaction of determinants, and on the transferability of high-income findings to developing settings.

2. Clarifying eHealth and mHealth

2.1. Concepts and electronic health literacy

Electronic health, or eHealth, refers to the cost-effective and secure use of information and communications technologies in support of health and health-related fields, including service delivery, surveillance, literature, education, knowledge, and research (WHO, 2016; Witten & Humphry, 2018) [109, 108]. Technology-enabled care is a subdomain encompassing telehealth modalities, monitoring devices, mobile applications, and patient portals. Within this broader field, mHealth denotes the use of portable electronic devices, such as smartphones, tablets, personal digital assistants, and wearable technologies, to facilitate healthcare provision, disseminate information, and gather data (Moss *et al*., 2019; Laing *et al*., 2018; Marufu & Maboe, 2017) [64, 51, 58]. Positioned within the framework of eHealth, mHealth has become an instrument for high-quality, accessible, and inclusive care.

Realising the value of mHealth depends not only on device availability but also on electronic health literacy, defined as the ability to seek, find, understand, and appraise health information from electronic sources and apply the knowledge gained to a health problem (Witten & Humphry, 2018) [108]. This entails several core literacy skills, including scientific, information, media, traditional, and computer literacy. Contemporary modes of patient-provider communication include mobile phones, smartphones, electronic mail, voice calls, texting, clinic-based video, personal monitoring devices, dashboards, individual health records, web-based portals, networking sites, and secure forums (Fortney *et al*., 2011) [29]. The WHO Global Observatory for eHealth defines mHealth as public-health practice supported by mobile devices, including patient monitoring devices, cell phones, personal digital assistants, and other wireless devices (WHO, 2017) [110].

2.2. The importance of mHealth and health reform

The healthcare sector presents obstacles to viable development, especially in low-income countries with a high prevalence of debilitating illness, and electronic and mobile health have become prominent components of healthcare reform (Moss *et al*., 2019) [64]. Although telehealth and telemedicine also rely on telecommunications, the emphasis on mobility differentiates mHealth and confers advantages of portability, immediacy, interactivity, and ubiquity (Ajala *et al*., 2015; Alam *et al*., 2020) [4, 7]. The capacity of information and communications technology to address inadequate access and reduce costs is especially salient in settings where chronic and communicable diseases coincide with weak infrastructure, and where ageing populations and rising expenditure necessitate new models of care (Alam *et al*., 2020; Latif *et al*., 2017) [7, 52].

Framed as a component of health-system reform, mHealth is significant not only as a clinical tool but as a developmental one, since the constraints it addresses, namely distance, cost, workforce scarcity, and fragmented information, are simultaneously health and development challenges (Moss *et al*., 2019) [64]. This framing helps explain why mHealth has attracted interest from governments and international actors as a lever for progress toward maternal and child health goals, and why its benefits are typically realised only when technological provision is accompanied by complementary reforms in financing, workforce, and governance. It also cautions against treating mHealth as a stand-alone fix, since tools introduced without attention to the surrounding system tend to remain at the pilot stage rather than becoming embedded in routine care (Latif *et al*., 2017) [52].

2.3. Mobile phone utilities for adoption

mHealth encompasses the adoption and exploitation of the intrinsic utility of mobile phones, notably voice communication and text messaging, augmented by advanced functionalities supported by third, fourth, and fifth generation mobile telecommunication systems, general packet radio service, global positioning systems, and Bluetooth technologies (Witten & Humphry, 2018) [108]. The widespread adoption of tablets and smartphones has facilitated the proliferation of mHealth applications globally, and the count of available applications has grown rapidly (Lee *et al*., 2020) [53]. High levels of mobile network coverage and broadband access in many regions have facilitated the integration of mobile devices into healthcare practice (Ray *et al*., 2011; Wallis *et al*., 2017) [82, 106].

2.4. Functional applications of mHealth in the health sector

mHealth supports health services through mobile devices and is used by professionals according to their specialisation to deliver timely, quality care. Its serviceable functions are commonly grouped into health information retrieval, covering inquiries and protocols for common conditions; remote reservation, covering registration and scheduled consultation; remote diagnosis and monitoring, in which physiological data are recorded and transmitted for real-time analysis; access to electronic medical records; and health consultation, including periodic advisories, disease-mitigation guidance, appointment reminders, and specialised notifications (Singh *et al*., 2016; Shen *et al*., 2019) [92, 91]. Compared with eHealth more broadly, mHealth offers superior portability, interactivity, and ubiquity, with features of customisation and universality. Despite considerable scholarly interest, empirical investigation of the interplay between social and psychological factors and mHealth adoption remains comparatively limited (Sun *et al*., 2013; Octavius & Antonio, 2021) [96, 68].

These functional categories map onto the maternal-care pathway in ways that clarify where mHealth is most likely to add value. Information retrieval and health consultation support the routine guidance and reassurance that sustain antenatal and postnatal engagement; remote reservation supports the scheduling that keeps women in contact with services; and remote diagnosis and monitoring, together with timely consultation, support the early recognition and escalation of complications. Access to electronic records, where it exists, links these functions across visits and providers. In practice, however, the functions realised in any given setting are bounded by the available modalities and infrastructure, so that consultation and information retrieval over voice and messaging are typically achievable while sophisticated monitoring is not. The gap between the full functional potential of mHealth and what is realised on the ground is therefore itself an object of analysis, and it recurs throughout the empirical literature reviewed below.

2.5. Trends in mobile application development

The history of mobile applications spans pre-application and post-application eras, reflecting the evolution from basic cell phones to smartphones. In the early 2000s, mobile telecommunication referred predominantly to text messaging and voice calls, which nonetheless transformed communication between patients and providers by enabling immediate exchange of health information and remote contact across distance. The proliferation of smartphones, with their enhanced hardware, internet connectivity, sensors, and media capabilities, precipitated a surge in mHealth services and made mobile devices a primary target for electronic health interventions. The establishment of curated application marketplaces consolidated personalised and mobile healthcare concepts within centralised repositories, facilitating widespread dissemination and allowing developers to reach large subscriber bases (Singh *et al*., 2016) [92]. Classifications of health and medical applications have identified tens of thousands of authentic healthcare applications, tailored both for providers and for patients, with usage projected to embed these tools within mainstream healthcare.

2.6. Patient engagement with mHealth applications

Patient engagement is central to the value of mHealth, since the benefit of any tool depends on sustained, meaningful use rather than mere availability. Frameworks for evaluating patient engagement, quality, and safety in mobile health applications emphasise that applications should be assessed not only for clinical content but also for the degree to which they support active participation by patients (Singh *et al*., 2016) [92]. Health application possession is common among smartphone owners in some settings, yet possession does not guarantee engagement, and behavioural logfile analyses show that the intensity and timing of use vary with user characteristics and circumstances (Shen *et al*., 2019; Guan *et al*., 2019) [91, 37]. Structured engagement and follow-up workflows, including reminders and scheduled contact, can help convert availability into sustained use, particularly in settings where awareness is the binding constraint (Eyetsemitan *et al*., 2024) [28]. Cost-benefit considerations and the perceived usefulness of applications further shape whether patients persist in their use (Rita, 2021; Lee & Moon, 2016) [83, 54].

A hierarchical engagement model, sometimes depicted as an engagement pyramid, describes how applications serve patients at different levels of involvement, from less active patients who face social or literacy barriers and benefit from data recording, training, and reminders, to highly activated patients who manage records and engage directly with providers (Singh *et al*., 2016; Witten & Humphry, 2018) [92, 108]. Less active patients may receive online assistance and motivation through gamification, in which game-design elements such as point scoring are used to sustain participation; medication-management applications that combine reminders, refill alerts, and interaction-warnings with such techniques illustrate how engagement can be supported across the spectrum (Singh *et al*., 2016) [92]. The quality of applications across this spectrum is judged by the reliability, accessibility, and usability of information, and by two safety concerns: the handling of dangerous information entered by a patient and the protection of patient privacy and security. Evidence that a large share of application users track at least one health indicator, and that patients with chronic or terminal conditions track more actively than healthy adults, indicates that the proliferation of health applications is partly demand-driven, although interoperability and the willingness of health systems to engage with streams of mHealth data remain obstacles to scaling (Singh *et al*., 2016) [92].

2.7. Health professional engagement with mHealth

Provider engagement strongly conditions patient adoption, since patients tend to trust health-related advice from their providers, and the level at which practitioners use mHealth shapes patients' intentions to use it (Balogun *et al*., 2020) [11]. Provider willingness and knowledge vary with role, education, and setting: studies report differing levels of knowledge and willingness among doctors, nurses, and gynaecologists, and consistently find that better-educated providers are more likely to adopt (Adebara *et al*., 2017; Tadayon *et al*., 2021; Marufu & Maboe, 2017) [1, 98, 58]. Systematic reviews of provider adoption identify recurrent enablers and barriers, including training, workload, infrastructure, and organisational support (Gagnon *et al*.,

2016) [31]. The social media practices of healthcare professionals also reshape relationships with patients, with implications for how mHealth is integrated into care (Smailhodzic *et al*., 2016) [93].

3. Principal mHealth Service Modalities

3.1. Voice calls and the public switched telephone network

Voice communication over telephone networks remains the most basic and widely used mHealth modality, enabling direct contact between patients and clinicians and the exchange of advice without travel. Before the spread of mobile telephony, the public switched telephone network served primarily affluent users because of its cost-intensive nature. The subsequent proliferation of digital electronics and mobile networks extended connectivity to remote areas, enabling communication through individualised mobile identifiers (Ray *et al*., 2011; Wesolowski *et al*., 2012) [82, 107]. In maternal care, voice calls support consultation, reassurance, and the prompting of timely presentation, and they are accessible to users with limited literacy or basic handsets.

3.2. Voice over internet protocol

Voice over internet protocol permits voice calls over a broadband connection, allowing users to reach others over the internet and, through interconnected services, to and from conventional landlines (Shaw & Sharma, 2016) [90]. A significant advantage of the modality is the capacity for long-distance and international communication at relatively low cost, with the flexibility of using a single number globally (Ghafarian *et al*., 2016) [32]. Consumer services such as WhatsApp and Facebook calls fall within this category and are increasingly used for informal clinical communication, although their security and privacy properties require attention when health information is exchanged.

3.3. Video conferencing

Video conferencing provides synchronous, omnipresent communication, affording contemporaneous face-to-face engagement using internet-enabled devices (Billingsley, 2020; Sandhu *et al*., 2023) [14, 85]. A range of applications is commercially available, including Zoom, Zoho Meeting, Skype, Google Hangout, Eyeson, GoTo Meeting, Cisco Webex, and Signal (Gray *et al*., 2020; Hacker *et al*., 2020; Freeman & De Decker, 2021) [36, 38, 30]. Contemporary applications offer real-time messaging, audio-visual recording, screen and document sharing, interactive polling, breakout rooms, and digital whiteboarding, enhancing interaction and enabling professionals to project social presence in digital environments, with advantages of time efficiency, convenience, and adaptability (Gray *et al*., 2020; Sandhu *et al*., 2023) [36, 85]. Scholarly work has examined behavioural propensities, research methodologies, and collaborative-learning uses of these applications (Maican *et al*., 2019; Sarwar *et al*., 2019) [57, 87], while privacy-calculus perspectives highlight the trade-offs users weigh in adopting them (Sandhu *et al*., 2023) [85].

3.4. Instant messaging and short message services

Instant messaging is an internet-based protocol application permitting communication across devices, and in some contexts it has displaced electronic mail as the preferred mode of distance communication. Short message and multimedia messaging services have attracted very large subscriber bases (Serik & Balgozhina, 2014) [89]. Messaging systems require fast, instantaneous communication and must provide the reliability, availability, and security expected of end users, while protecting the privacy of information. Modern messaging software integrates data transfer, voice chat, and video, and is valued for performance in communication and interaction as well as for informal use. Text messaging in particular has been used to support maternal health communication and reminders in Nigeria and elsewhere, given its low cost and broad reach (Omole *et al*., 2018; Oyeyemi & Wynn, 2014) [76, 79].

For maternal care in low-resource settings, messaging occupies a strategic position between voice and richer platforms. It is asynchronous, which suits women who cannot take calls during work or who prefer discreet contact; it is inexpensive and works on basic handsets; and it lends itself to structured, repeatable content such as appointment reminders, antenatal and postnatal prompts, and danger-sign advice. These properties have made short messaging a workhorse of maternal mHealth interventions, although its effectiveness depends on literacy, language, and the ability to sustain two-way interaction rather than one-way broadcast. Where literacy is a barrier, voice notes and interactive voice response can extend the reach of messaging-style content, illustrating how modalities are often combined rather than used in isolation (Omole *et al*., 2018; Oyeyemi & Wynn, 2014) [76, 79].

4. Theoretical Frameworks

4.1. Unified Theory of Acceptance and Use of Technology

The Unified Theory of Acceptance and Use of Technology (UTAUT) is widely used in technology adoption research. Formulated by Venkatesh and colleagues through an examination and synthesis of eight prior models, including the Theory of Reasoned Action, the Technology Acceptance Model, the Theory of Planned Behaviour, the Model of Personal Computer Use, Social Cognitive Theory, the Motivational Model, a combined planned behaviour and acceptance model, and Diffusion of Innovations, it aims to explain users intentions to use information technology and their subsequent behaviour (Venkatesh *et al*., 2003) [104]. Validation showed that the model accounted for around 70 percent of the variance in behavioural intention and about half of actual use.

The theory posits four constructs. Performance expectancy is the extent to which an individual believes that using the system will help accomplish a task; in the mHealth context it reflects the belief that a mobile phone can be used to access care, and therefore the importance of the technical know-how required. Effort expectancy is the ease of use associated with adoption; it reflects how comfortable people are with using a mobile phone to reach health facilities. Social influence is the degree to which use depends on how others perceive the technology's importance, encompassing the influence of neighbours, community, and social circle. Facilitating conditions describe the extent to which individuals and organisations are willing and able to support the technology, including whether government and health centres provide the technical and infrastructural support required. Performance expectancy, effort expectancy, and social influence directly influence behavioural intention, while facilitating conditions act more directly on use, and the effects are moderated by gender, age, experience, and voluntariness (Venkatesh *et al*., 2003) [104]. The framework guides managers and decision-

makers in assessing the efficacy of technology implementation in institutional and healthcare settings, and has been applied and extended in mHealth acceptance studies (Sun *et al*., 2013; Alam *et al*., 2018; Octavius & Antonio, 2021; Liang *et al*., 2010) [96, 8, 68, 56].

Applied to maternal mHealth, the four constructs translate into testable expectations. Performance expectancy predicts that women who believe mobile contact will meaningfully improve their access to care are more inclined to adopt; effort expectancy predicts that those comfortable with the relevant tools face a lower barrier; social influence predicts that endorsement by providers, partners, and peers raises uptake; and facilitating conditions predict that the presence of supportive infrastructure and institutional backing converts intention into use. The moderating roles of age, gender, and experience are especially pertinent for a reproductive population whose members span a wide age range and differing levels of exposure to technology. This translation makes UTAUT a useful organising lens, while its limitation, a primary focus on individual perceptions, is precisely what the socio-ecological model is introduced to complement.

4.2. The socio-ecological model

The socio-ecological model addresses the criticism that the health sector often focuses on individual lifestyle while neglecting the contextual forces that surround behaviour (Stokols, 1992) [94]. It holds that individuals are embedded within larger social systems and that interactions within those systems underlie health outcomes. Introduced as a concept and later developed into a theory, it has been revised by Bronfenbrenner and others (Bronfenbrenner, 1977, 1986) [18, 19]. The model initially assumed that an individual's ecological structure and biological nature must be considered in understanding behaviour and development, and it was developed to express level-specific influences and possible interventions at each level (McLeroy *et al*., 1988) [61]. Intrapersonal interventions target knowledge, beliefs, and skills; interpersonal and institutional interventions reshape relationships and organisational environments; and community interventions seek to expand services or empower disadvantaged groups (McLeroy *et al*., 1988; Glanz *et al*., 2018) [61, 34].

The model affirms that multiple levels of influence exist and that these forces are interactive and reinforcing, so that adopting any technology to improve health is most effective when all levels are targeted simultaneously (Stokols, 1996) [95]. Applied to mHealth, commonly distinguished levels include the individual level, comprising traits such as age, education, and economic status; the interpersonal or household level, comprising social networks, relatives, friends, and colleagues whose use of technology can shape an individual's adoption; the community level, comprising networks between organisations and institutions; the organisational level, comprising institutions that enforce behaviour-shaping rules; and the policy or enabling environment, comprising laws and policies at local, national, and global levels. Interpersonal relationships exert a pronounced influence on health behaviour, including the pursuit of care and the assimilation of novel technologies (Thoits, 2010; Umberson & Karas Montez, 2010; Okafor *et al*., 2018) [99, 101, 71]. The model has been applied to immunisation and technology uptake in Nigeria (Olaniyan *et al*., 2021) [74] and to the behavioural intention to recommend mHealth innovations (Oloveze *et al*., 2022) [75]. Combined with UTAUT, it frames adoption as a product of internal factors, namely individual characteristics and household factors, and external factors, namely community, government, and infrastructural conditions.

5. Empirical Evidence on Barriers and Determinants

5.1. Global and regional perspectives

Policymakers in both developed and developing countries have recognised the potential of mobile devices to improve the health sector. A WHO Global Observatory survey assessed the position of mHealth across member states using categories that included health treatment compliance, emergency telephone services, disaster management, surveillance, mobile telemedicine, appointment reminders, community mobilisation, health promotion, call centres, mobile patient records, information access, patient monitoring, health education, decision support, and health surveys (Ryu, 2012a) [84]. The survey documented adoption of initiatives, types of initiatives, evaluation status, and implementation barriers. It found that results-based evaluation of mHealth was uncommon, with only a small minority of member states reporting evaluation services, and that most programmes remained at pilot or informal stages. Advanced economies showed more extensive mHealth activity than lower-income countries, and financial constraints, staff scarcity, and contending health-system priorities hindered implementation.

Reviews of mHealth and eHealth in sub-Saharan Africa describe substantial promise alongside persistent implementation challenges (Bervell & Al-Samarraie, 2019; Latif *et al*., 2017; Njoroge *et al*., 2017) [13, 52, 66]. The transformative potential of mobile phone adoption for health is driven by rapid advances in mobile usage and applications, opportunities for integrating mHealth into existing eHealth services, and the continued growth of mobile cellular networks. Realising that potential in low-income settings requires concerted action by governments, policymakers, stakeholders, professionals, developers, researchers, and the telecommunications industry to address common barriers (Latif *et al*., 2017) [52].

The survey evidence gives a sense of the global distribution of activity. Across the responding member states, a large majority reported some form of mHealth service, though many offered only a handful of programmes, and the most frequently reported initiatives were health call centres, emergency toll-free telephone services, the management of emergencies and disasters, and mobile telemedicine (Ryu, 2012a; Fortney *et al*., 2011) [84, 29]. With the exception of those few categories, roughly two-thirds of mHealth programmes remained at the pilot or informal stage, and only a small minority of states reported any results-based evaluation of their initiatives, which the survey identified as a central obstacle to sustainable adoption. Surveillance, awareness, and decision-support applications were comparatively rare, and African countries were generally less active than those in the European region, reflecting the influence of financial constraints, staff scarcity, and competing health-system priorities on the capacity to implement and evaluate mHealth (Ryu, 2012a; Huang *et al*., 2020) [84, 41].

5.2. Barriers affecting adoption

In low-income countries, healthcare infrastructures face perennial challenges in delivering cost-effective, high-quality

care amid rising chronic and communicable disease (Kruse *et al*., 2019) [50]. Many deaths from preventable conditions are attributable to illiteracy, inadequate awareness, lack of access, remoteness, and poverty. Despite the potential of mHealth to revolutionise services in regions with underdeveloped public-health systems, the pace of adoption remains insufficient (Latif *et al*., 2017) [52]. A key conceptual point is that access is necessary but not sufficient for adoption: the re-conceptualisation of access in the digital age must accompany a re-conceptualisation of adoption, and improving digital access alone does not guarantee improved outcomes (Fortney *et al*., 2011; Alam *et al*., 2020) [29, 7]. The barriers affecting access, spanning geographical, temporal, cultural, financial, and digital dimensions, closely mirror the barriers affecting adoption (Al-Radaideh & Alazzam, 2020) [6]. Determinants of hospital adoption have likewise been characterised in technological, organisational, and environmental terms (Ngongo *et al*., 2019) [65].

5.3. Contextual factors and the classification of determinants

Contextual factors describe environmental, health-provider, and behavioural-individual level influences, and ecological theory provides the backbone for their analysis (Phillips *et al*., 1998; Bronfenbrenner, 1977) [80, 18]. The literature shows frequent overlap in the classification of factors: some studies treat individual and household factors together, others fold sociocultural, political, and economic factors into individual and community categories, and still others consider healthcare practices and technology-acceptance behaviour as individual factors (Pokhrel & Sauerborn, 2004; Tadayon *et al*., 2021; Sun *et al*., 2013) [81, 98, 96]. Behavioural models distinguish predisposing elements such as gender, age, profession, and education; enabling factors such as income and household resources; and need factors such as illness perception, all grounded in determinants of decision-making including economic conditions, proximity to facilities, prior satisfaction, and perceived quality (Pokhrel & Sauerborn, 2004) [81]. The sections that follow review individual, household, and community determinants in turn.

5.4. Age

Age is a useful demographic parameter linked with health, either alone or in combination with other factors, and vulnerability varies across the life course. Globally, ageing populations coincide with rapid population growth in many developing countries, and the convergence of chronic and infectious disease is a significant concern. Age is consistently identified as a major parameter in adopting new technologies, with acceptance rates varying across age groups (Sun *et al*., 2013; Lee *et al*., 2020) [96, 53]. Among providers in Nigeria, age has been positively associated with mHealth knowledge (Balogun *et al*., 2020) [11]. Studies of technology-enabled care report that such care is most common among younger, well-educated persons, while older adults with chronic conditions may derive particular benefit from interactive, feedback-enabled, and self-management care (Witten & Humphry, 2018) [108]. Age also moderates the relationship between the UTAUT constructs and behavioural intention (Al-Radaideh & Alazzam, 2020; Alam *et al*., 2020) [6, 7].

The pattern of use within age groups is itself informative. Analyses based on electronic health literacy instruments find the main statistical differences in technology-enabled care to fall along education and age lines, with younger and well-educated persons most likely to adopt, and with distinct ownership and usage profiles by age band: smartphones and internet features are concentrated among younger adults, while older groups more often own basic handsets and landlines yet stand to gain most from monitoring and feedback-enabled care for chronic conditions (Witten & Humphry, 2018) [108]. The effects of demographic change on adoption are therefore not straightforward and depend on whether the progressive nature of ageing is considered alongside non-demographic factors, a nuance that is especially relevant in developing countries where the age structure is shifting rapidly (Bahjuri-Ali, 2007) [10]. For reproductive populations specifically, the implication is that age-tailored design and outreach may be needed rather than a single undifferentiated approach.

5.5. Gender

Health structures are not gender-neutral, since gender is a significant social stratum that affects health needs, experience, and outcomes (Nowatzki & Grant, 2011) [67]. Disparities in mobile phone access between women and men are estimated at about 14 percent in sub-Saharan Africa and higher in parts of South Asia, often reflecting patriarchal social structures (Alam *et al*., 2020) [7]. Concerns specific to women, including conditions associated with ageing and the heightened risk of poverty and social isolation among widowed or single women, imply that mHealth applications for this demographic should accommodate multifaceted needs. Although the influence of gender on buying behaviour has been examined extensively, its influence on mHealth adoption has been comparatively sparsely studied, and empirical work underscores gender as a pertinent factor in technology acceptance (Borrero *et al*., 2014; Celik & Ipcioglu, 2007) [17, 21].

For maternal and reproductive health, the gender dimension is not incidental but constitutive, since the users in question are women whose access to devices, autonomy in decision-making, and exposure to health information are themselves gendered. Where mobile ownership and control sit disproportionately with men, women's independent use of mHealth can be constrained even when household-level access exists, which links the gender question to the household-autonomy literature and to the design of interventions that reach women directly (Alam *et al*., 2020; Idriss-Wheeler & Yaya, 2021) [7, 43]. The relative scarcity of dedicated study of gender and mHealth adoption, against the salience of gender for maternal care, is itself a gap that this review highlights and that motivates attention to women-centred design and outreach.

5.6. Education and patient knowledge

Education and electronic health literacy shape the capacity to seek, find, understand, and appraise health information. Studies in low-income countries report limited knowledge of mHealth, with good knowledge among only a minority of respondents in some Nigerian and other African samples, in contrast to higher knowledge among providers in some high-income settings (Bello *et al*., 2004; Gilano *et al*., 2024; Desouza *et al*., 2014) [12, 33, 25]. The level at which practitioners use mHealth affects patients intentions to use it, since patients tend to trust health advice from providers (Balogun *et al*., 2020) [11]. Better-educated primary healthcare providers are markedly more likely to adopt mHealth, and higher education is associated with greater mHealth

knowledge (Adebara *et al*., 2017; Balogun *et al*., 2020) [1, 11]. In developing countries, barriers of literacy and sustainable income must be addressed when promoting eHealth and general health behaviour among women, and the odds of mobile phone use are substantially lower among those who never attended school (Bishwajit *et al*., 2017) [15].

The education gradient operates on both the supply and demand sides of care. On the supply side, the share of highly educated primary-care providers adopting mHealth has been reported to exceed that of less-educated providers by a wide margin, and provider education is associated with measurably higher mHealth knowledge scores, which matters because provider use conditions patient use (Adebara *et al*., 2017; Balogun *et al*., 2020) [1, 11]. On the demand side, schooling is associated with the likelihood of mobile phone use even among women in the same locality, so that the absence of formal education can depress use independently of access (Bishwajit *et al*., 2017) [15]. For maternal and reproductive health, where the coverage and quality of services are often inadequate, this dual pathway suggests that literacy-sensitive design, the use of voice rather than text where reading is a barrier, and provider-led demonstration are likely to be important for reaching less-educated women without excluding them (Olajubu *et al*., 2020) [72].

5.7. Marital status

The application of mHealth must be compatible with the phases of human existence and suitable for individual health-management needs. Marital status, classified as single, married, separated, or divorced, is significantly related to quality of life, which in turn relates to access to health services and technology. The effect of marital status on mHealth differs by gender and age, and marital status has been found to be significantly associated with knowledge of mHealth (Han *et al*., 2014; Adebara *et al*., 2017) [39, 1]. Harnessing mHealth to assist healthcare delivery to widely dispersed women can increase access to reproductive health services and reduce maternal mortality (Olajubu *et al*., 2020) [72].

For reproductive women, marital status interacts with autonomy and support in ways that bear directly on adoption. Married women may benefit from spousal resources and encouragement but may also face constraints where decisions about devices and care rest with a partner, whereas single, separated, divorced, or widowed women may have greater independence in decision-making but fewer material resources and, in some contexts, heightened exposure to social and economic vulnerability. Because these countervailing influences can pull adoption in opposite directions, the net effect of marital status is likely to be context-dependent and entangled with age, education, and household economic position, which argues for analysing marital status jointly with other determinants rather than in isolation (Han *et al*., 2014; Pokhrel & Sauerborn, 2004) [39, 81].

5.8. Religion and culture

Religious belief and cultural practice influence health-seeking behaviour and the acceptance of modern health technology. Evidence from northern Nigeria indicates that, despite high antenatal attendance, a substantial proportion of women deliver at home and maternal mortality remains far higher than in the southwest, which records the lowest rate, reflecting the interplay of cultural, religious, and structural factors (Idris *et al*., 2013; Udenigwen *et al*., 2022) [42, 100]. The influence of cultural and ethnic diversity on adoption, and the importance of culturally tailored interventions, are recurring themes in the broader mHealth literature (Gonzalez *et al*., 2021) [35].

Because religion and culture shape both the perceived legitimacy of mediated care and the channels through which health messages are trusted, they bear on the social-influence construct of acceptance theory and on the community level of the ecological model. Faith and community institutions can serve as conduits for credible health communication, and aligning mHealth messaging with local norms and trusted intermediaries may improve uptake where technology alone would not. At the same time, cultural preferences for in-person or traditional care, and concerns about the propriety of remote contact for sensitive reproductive matters, can dampen adoption. The regional contrast within Nigeria illustrates that these cultural and structural influences are intertwined, so interventions are likely to be more effective where they are culturally tailored and delivered through locally trusted channels rather than applied uniformly (Idris *et al*., 2013; Gonzalez *et al*., 2021) [42, 35].

5.9. Occupation

Adoption differs by occupation and occupational setting. With fewer workers engaged in primary industry and more in sedentary work, workplace health promotion using self-monitoring and self-motivating applications has become useful, and individuals whose occupations leave little time to access care may engage more with such tools (Melzner *et al*., 2014) [62]. Occupational status also shapes the categories of applications used and the temporal patterns of use: managerial and professional users engage more with training and coaching applications, while students and unemployed individuals show more consistent weekday and weekend use, and workers and managers show diminished weekday engagement (Guan *et al*., 2019) [37].

For reproductive women in developing settings, occupational influence intersects with employment status and time availability in distinctive ways. Unemployed women and those in informal or home-based work may have both the time and the need to rely on mediated contact with providers, whereas formal employment can either facilitate use, through better resources, or constrain it, through limited time during working hours. Because occupational categories in these settings differ from those in the high-income studies that dominate the literature, the temporal and categorical patterns reported elsewhere should be applied with caution, and local evidence is needed on how women's work shapes when and how they use mHealth for maternal care (Guan *et al*., 2019; Melzner *et al*., 2014) [37, 62].

5.10. Electronic health literacy and chronic morbidities

Studies report an upsurge in patients seeking medication-related information or care through mobile phones and the internet in both developed and developing countries (Desouza *et al*., 2014; Ray *et al*., 2011) [25, 82]. Electronic health literacy conditions the capacity to use these channels effectively, and is most developed among younger and better-educated users (Witten & Humphry, 2018) [108]. Chronic morbidities create sustained needs for monitoring and adherence support, for which mHealth tools and interventions to improve medication adherence have been examined, with mixed but promising results (Viswanathan *et al*., 2012;

Scholz & Teetz, 2022) [105, 88].

Electronic health literacy is more than the ability to operate a device; it combines scientific, information, media, traditional, and computer literacy, and it governs whether users can find, appraise, and act on health information rather than simply receive it (Witten & Humphry, 2018) [108]. This distinction matters for maternal care, because a woman may be fully capable of making calls and sending messages yet less able to evaluate competing health information or to act confidently on remote advice, which can blunt the benefit of otherwise accessible tools. The literacy lens therefore complements the education determinant: interventions that assume basic operational skill but neglect appraisal and decision-making may overestimate their reach, whereas designs that build interpretive support into the service, through trusted provider contact and clear, actionable guidance, are more likely to translate access into improved outcomes (Witten & Humphry, 2018; Desouza *et al*., 2014) [108, 25].

5.11. Perceived privacy risk

Perceived privacy risk can deter adoption where users are uncertain how their information will be handled. The availability and quality of mobile health application privacy policies are variable, and many applications do not meet the protections expected of health data (Sunyaev *et al*., 2015) [97].

As consumer messaging and video-conferencing channels are increasingly used for clinical communication, privacy-calculus considerations shape adoption decisions (Sandhu *et al*., 2023; Guan *et al*., 2019) [85, 37], and secure data architectures and governance for healthcare organisations become increasingly important (Mbonu *et al*., 2024) [59].

In maternal and reproductive health, privacy concerns acquire particular weight because the information exchanged is sensitive and because disclosure can carry social as well as clinical consequences. Where care is mediated through general-purpose consumer applications rather than purpose-built clinical systems, the boundary between private and shared information is easily blurred, and uncertainty about who can access messages may discourage candid communication about reproductive matters. The literature therefore frames privacy not as a downstream compliance issue but as an upstream determinant of whether women adopt and trust mHealth, which argues for transparent handling of information, appropriate safeguards at the facility level, and attention to the data-governance arrangements that underpin sustainable services (Sunyaev *et al*., 2015; Mbonu *et al*., 2024) [97, 59].

5.12. Household socioeconomic position and women's autonomy

Household income, family structure, headship, and decision-making shape the resources available for technology adoption and care-seeking, and frequently mediate women's autonomy in accessing services (Pokhrel & Sauerborn, 2004; Bahjuri-Ali, 2007) [81, 10]. Household economic position and women's empowerment influence the use of maternal services, and disparities in phone ownership within households can constrain women's independent use (Idriss-Wheeler & Yaya, 2021; Leight & Wilson, 2021; Blumenstock & Eagle, 2012; Mohan *et al*., 2020) [43, 55, 16, 63]. These household dynamics are often under-examined relative to individual factors, particularly in developing-country contexts (Yaya *et al*., 2019) [111].

The socio-ecological framing places these household factors at the interpersonal level, where social networks of relatives, friends, and colleagues exert pronounced influence on whether a woman takes up a new technology, especially where someone within her social circle already uses such tools to access care (Thoits, 2010; Umberson & Karas Montez, 2010) [99, 101]. Family type, headship, and partner education can therefore operate either as enablers, when household members model and endorse mHealth use, or as constraints, when control over devices and decisions rests with others. Because the direction and magnitude of these effects appear to vary across settings, with some studies finding household structure decisive and others finding it secondary to economic position, the household level warrants explicit measurement rather than assumption, particularly for reproductive women whose care-seeking is often embedded in family decision-making (Pokhrel & Sauerborn, 2004; Okafor *et al*., 2018) [81, 71].

5.13. Place of residence and regional differences

Place of residence and regional infrastructure condition the practical possibility of using mobile channels for care. Rural-urban gaps in the determinants of maternal and child health outcomes are documented across sub-Saharan Africa (Yaya *et al*., 2019) [11], and the spatial distribution of facilities and weak primary-care performance compound access barriers in Nigeria (Sanni, 2010; Kress *et al*., 2016) [86, 49]. Mobile health technology has been proposed as a means of reducing health disparities in underserved communities by spanning geographical barriers (Van Veen *et al*, 2019; Desouza *et al*., 2014) [103, 25], and infrastructure-driven expansion of services across underserved and rural regions is central to equitable access (Aminu-Ibrahim *et al*., 2020) [9].

Regional differences also carry a programmatic dimension that geography alone does not capture. Within a single country, states and districts differ in the presence and design of mHealth initiatives, in the resourcing and integration of services, and in the health-system routines that determine whether available tools are used, so that residence acts partly as a proxy for the local policy and organisational environment (Ngongo *et al*., 2019; Ajayi & Akpan, 2020) [65, 5]. This has two implications for the literature. First, comparisons across regions should attend to programme context and not only to urbanicity or infrastructure. Second, the apparent effect of residence may be modifiable through deliberate programme design, which makes regional disparity a target for intervention rather than a fixed constraint (Zayyad & Toycan, 2018) [113].

5.14. Income, poverty, community infrastructure, and cohesion

Income inequality and poverty constrain both access to and adoption of mHealth, since cost remains a salient barrier in resource-limited settings. At the community level, the availability of mobile networks, internet access, power supply, and the condition of public infrastructure are decisive for adoption (Buor, 2003; Hjortsberg, 2003; Zayapragassarazan & Kumar, 2016) [20, 40, 112]. Community cohesion and the networks between organisations and institutions shape how populations behave and which health practices they uphold, consistent with the community and organisational levels of the socio-ecological model. Sustainable adoption of e-health in developing countries therefore depends on addressing infrastructural and

organisational conditions alongside individual readiness (Zayyad & Toycan, 2018) [113].

These community and infrastructural determinants help explain why adoption can stall even where individual willingness is high. Intermittent network coverage, unreliable electricity, and the recurring cost of data or airtime impose practical limits that no amount of individual motivation can overcome, and they fall hardest on the poorest and most remote women, compounding existing inequities. Community cohesion can partly offset these constraints, since shared use, peer demonstration, and trusted local networks lower the perceived risk and effort of adoption, again connecting the infrastructural picture to the interpersonal and social-influence dimensions of adoption. The implication for policy is that demand-side measures must be matched by investment in the enabling environment, including connectivity and power, if the potential of mHealth is to be realised equitably (Kruse *et al*., 2019; Zayyad & Toycan, 2018) [50, 113].

6. mHealth for Maternal and Reproductive Health in Sub-Saharan Africa

6.1. Regional evidence

Maternal and reproductive applications of mHealth in the region range from short-message reminders and patient-held records to provider-facing surveillance and training tools (Omole *et al*., 2018; Itanyi *et al*., 2023; Otu *et al*., 2021) [76, 44, 77]. Provider-based studies report positive but uneven effects on maternal and child health, and qualitative work highlights both enablers and barriers to acceptability in rural settings (Gilano *et al*., 2024; Udenigwen *et al*., 2022) [33, 100]. Programme theories such as that underlying MomConnect in South Africa illustrate how mHealth initiatives are expected to work and where they may falter (Kabongo *et al*., 2020) [47]. Disparities in mobile phone access continue to shape maternal service utilisation, underscoring the equity dimension of adoption (Jennings *et al*., 2015; Jennings & Gagliardi, 2013; Bishwajit *et al*., 2017) [46, 45, 15].

Across the region, the functional emphasis of maternal mHealth has fallen on adherence support, diagnosis, reminders, field reporting, observation, training and recruitment, referrals, disease prevention, record management, and treatment information (Bervell & Al-Samarraie, 2019) [13]. These applications target the points in the maternal-care pathway where continuity of contact is most fragile, namely antenatal follow-up, the prompting of facility delivery, and postnatal care, and they are intended to compress the interval between the recognition of danger signs and clinical response. Yet the regional literature is consistent in finding that effects are conditional on implementation quality, infrastructure, and the degree to which women actually adopt the tools, so that the same intervention can succeed in one setting and stall in another (Latif *et al*., 2017; Njoroge *et al*., 2017; Udenigwen *et al*., 2022) [52, 66, 100]. This conditionality reinforces the case for context-sensitive, multi-level analysis rather than generalisation from single programmes.

6.2. Nigerian programmes and applications

In Nigeria, mobile health interventions have improved postnatal care uptake and shaped maternal experiences of care, and programmes such as Abiye in Ondo State have used registration and mobile linkage to support safe motherhood objectives (Olajubu *et al*., 2020, 2022; Ajayi & Akpan, 2020) [72, 73, 5]. Mobile applications for pregnancy, birth, and child care have proliferated, although their quality and patient-engagement value vary (Lee & Moon, 2016; McKay *et al*., 2011; Melzner *et al*., 2014; Rita, 2021) [54, 60, 62, 83]. The COVID-19 period accelerated interest in remote care and the use of mobile tools for training and surveillance, while exposing fragilities in health systems and information environments (Ebenso & Otu, 2020; Ejeh *et al*., 2020; Adeniyi *et al*., 2020; Otu *et al*., 2021; Huang *et al*., 2020; Umeanwe, 2021) [26, 27, 2, 77, 41, 102]. Childbearing women's perceptions of mHealth for maternal information have been examined in rural southwestern Nigeria, often revealing limited awareness despite available technology (Odetola *et al*., 2018; Chaka *et al*., 2020; Dasuki & Zamani, 2019) [69, 22, 24].

Beyond individual programmes, the Nigerian evidence reflects a wider tension between rapid technological availability and uneven uptake. mHealth has been promoted as a means of reducing the marked regional disparities in maternal mortality within the country, on the premise that improving women's access to and knowledge of mobile phones and applications can extend reproductive-health services to dispersed and underserved populations (Jennings *et al*., 2015; Kola *et al*., 2021) [46, 48]. At the same time, applications are frequently tried in fragmented, project-based ways, and questions of interoperability, sustainability, and integration into routine care recur. The result is a landscape in which the supply of tools has grown faster than the structures needed to embed them, so that the decisive questions concern not whether technology exists but whether women adopt it and whether health systems sustain it (Olajubu *et al*., 2020; Udenigwen *et al*., 2022) [72, 100].

6.3. The Osun and Ondo context

Within the southwest, Osun and Ondo States illustrate contrasting starting points for mHealth in maternal care. Ondo State has operated the Abiye safe motherhood initiative, registering pregnant women and linking them to care through mobile phones, while Osun State has implemented an electronic medical record system at its university teaching hospital, although its broader health system has received limited mHealth attention (Ajayi & Akpan, 2020; Ogbonna *et al*., 2020; Sanni, 2010) [5, 70, 86]. The distribution of facilities in Osun has been described as unbalanced and not easily accessible to many rural residents, reinforcing the relevance of mediated channels of care (Ogbonna *et al*., 2020) [70]. These contrasts make the two states a useful setting for understanding how programme design and health-system context condition adoption.

7. Synthesis and Research Gaps

Three gaps emerge from this synthesis. First, much of the evidence is provider-centred, leaving patient perceptions, knowledge, and contextual barriers comparatively understudied, especially among reproductive women in developing settings (Dasuki & Zamani, 2019; Kola *et al*., 2021; Oyegoke, 2013) [24, 48, 78]. Second, contextual determinants are frequently examined in isolation rather than holistically across individual, household, and community levels, which the socio-ecological model suggests is necessary to capture how forces interact and reinforce one another (Stokols, 1992, 1996; Olaniyan *et al*., 2021) [94, 95, 74]. Third, developed-country findings on income and family structure may not transfer to Nigeria, where socio-

demographic conditions differ markedly, and the classification of determinants remains inconsistent across studies (Blumenstock & Eagle, 2012; Yaya *et al*., 2019; Pokhrel & Sauerborn, 2004).

A further gap concerns evaluation. The global evidence indicates that rigorous, results-based evaluation of mHealth is uncommon, and that many programmes remain at pilot or informal stages (Ryu, 2012a). Addressing these gaps calls for integrated, theory-driven studies that combine acceptance constructs with multi-level contextual analysis, that treat maternal and reproductive populations as a distinct focus, that attend to privacy and data governance as adoption matters rather than afterthoughts, and that incorporate longitudinal and comparative designs capable of linking adoption to clinical outcomes.

Synthesising across the determinant literature, a coherent picture emerges in which the technologies most likely to be adopted in resource-constrained settings are the simplest and most ubiquitous, in which adoption is shaped less by basic capability than by awareness, social endorsement, and facilitating conditions, and in which individual characteristics interact with household and community circumstances rather than acting alone. This picture aligns the acceptance and socio-ecological traditions: performance and effort expectancy speak to the perceived value and ease of the tools, social influence and facilitating conditions speak to the interpersonal, organisational, and policy levels of the ecological model, and the moderating roles of age, gender, and experience connect individual attributes to the wider context. The practical corollary is that interventions should be multi-level by design, combining demand-side awareness and encouragement with supply-side resourcing and supportive infrastructure, and should be tailored to the determinant profile of the specific population rather than imported wholesale from other settings.

8. Conclusion

mHealth holds substantial promise for extending maternal and reproductive healthcare in developing countries, but its adoption is governed by a layered set of conceptual, technological, and contextual factors. The relationship between availability, access, and adoption is central: availability and even access do not guarantee use, and the barriers that limit access closely mirror those that limit adoption. Anchoring analysis in the Unified Theory of Acceptance and Use of Technology and the socio-ecological model, and attending jointly to individual, household, and community determinants, offers the most coherent basis for understanding and improving uptake. The service modalities most likely to be adopted in resource-constrained settings are the most accessible ones, namely voice calls and messaging, which has both practical and equity implications for programme design.

Future work should prioritise patient-centred, multi-level studies in maternal and reproductive populations; pair the expansion of services with attention to awareness, provider engagement, infrastructure, and data privacy; and adopt rigorous, longitudinal, and comparative evaluation. If these conditions are met, the transformative potential of mHealth to improve reproductive health outcomes in sub-Saharan Africa and beyond can be realised more equitably and more durably than the current, uneven pattern of adoption suggests. In closing, the value of mHealth for maternal and reproductive health lies not in the sophistication of the technology but in the fit between accessible tools, the women who would use them, and the systems that must sustain them. The literature reviewed here points consistently to a gap between what is technologically possible and what is actually adopted, and locates that gap in awareness, social and institutional support, and contextual conditions as much as in capability. Closing it will require evidence that is patient-centred, theoretically integrated, and sensitive to the specific determinant profiles of the populations served, so that programmes are built around how reproductive women actually live and decide rather than around the assumed trajectory of the technology, and so that the promise of mobile health is matched by the realities of its uptake.

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