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Review of patients' perspectives of m-health adoption factors in the developing world. Development of a proposed conceptual framework

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ABSTRACT

Patient perceptions and experiences of mobile health (m-health) systems have been recognised as an important element to consider in the adoption of m-health based technologies. Though much research supports this, published studies that identify m-health use by patients appear to highlight these issues in an indirect rather than a holistic manner. Consequently, there is no encompassing framework that serves as a guide for effective implementation and maximum adoption of m-health from the perspective of patients in the developing world. This review identifies patient adoption issues specifically and uses these to develop a framework of patient adoption issues for m-health in the developing world. A structured literature search was conducted using PubMed and Scopus. For PubMed, a consolidated search string combined 'MeSH' terms and 'All Fields' terms for selected keywords. For Scopus, an equally consolidated search string was used. The searches were restricted to articles in English during the period January 1, 2000 to 31 December2019 and relevant to the developing world. Duplicate articles were removed. Titles and abstracts were screened by all authors for inclusion, and those studies that met the inclusion criteria were selected for full-text review. Review and data abstraction was performed by two authors. Fifty-four (54) articles reported factors that impact patient adoption. Initial review and data abstraction identified 22 categories that promote or impede m-health adoption by patients in the developing world. Continued iterative review reduced these to 7 primary categories, with 20 subcategories, which were used to design the proposed framework. The review showed: great inconsistency in the approach and tools used in published studies; multiple factors impact patient adoption of m-health in the developing world; the specific factors vary from setting to setting and by recency of findings. Successful adoption of m-health by patients in the developing world critically depends on addressing the factors identified in the proposed framework and assessing them prior to the implementation of m-health initiatives in any specific setting. The proposed framework will serve to increase the consistency of patient adoption studies and provide the foundation for greater success of future m-health implementations for patients in the developing world.

1. Introduction

The World Health Organization defines m-health, or mobile health (a component of e-health), as medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants, and other wireless devices [1]. The rationale for patients (and healthcare organisations) to adopt mobile healthcare has been to improve patient care, quality of services, efficiency, and safety, as well as to reduce costs, and involve individuals in their own health and healthcare management.

m-Health can use any form of mobile technology, engages and links all types of users, and has been - and is being - used in support of many aspects of health, healthcare, and healthcare delivery (including: monitoring and surveillance; behaviour change; prevention, promotion and awareness creation; and patient education), using both synchronous (real-time; e.g., videoconference) and asynchronous (delayed-time, e.g., e-mail, instant messaging) formats [2–6]. Mobile phones are the most commonly used devices by patients to remotely accept, organise, and

Abbreviations: AIDS, Acquired Immune Deficiency Syndrome; HIV, Human Immunodeficiency Virus; MeSH, Medical Subject Headings; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; SIM, Subscriber Identification Module; SMS, Short Message Service; USD, United States Dollar.

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transmit data [7]. Recently, many developing economies have invested more heavily in mobile telecommunication infrastructure than in road transport and electric power generation [1], to the potential benefit of m-health. This investment notwithstanding, those in the developing world who could benefit most from m-health's deployment, the rural poor, do not get appropriate attention [8]. Health-related solutions, technologies, and government and humanitarian efforts are usually geared towards stakeholders other than the patient, e.g., clinicians, managers, and health system payers. While technology acceptance research suggests that user perceptions, adherence and acceptance may constitute key factors for successful development and implementation of m-health technologies in general [1,9–11], factors specifically influencing patient adoption of m-health have not been summarised or categorised.

Similarly, differences in health issues between developed and developing countries have not been considered. Developing countries present different contexts and realities that must be considered [12]. For example, in developing countries: HIV/AIDS, tuberculosis, and malaria remain prevalent; maternal and child mortality remain unacceptably high; inadequate access and unstable power supplies are pervasive; skilled workforce shortages are more acute and they 'lack the capacity to build their capacity'; and district health systems are understaffed and under-resourced, particularly in rural and remote locations [2,12]. In addition, extreme poverty is more rampant with millions of people living on less than $1.90 USD a day, with the situation being summed up as follows: "The poorest in the world are often hungry, have much less access to education, regularly have no light at night, and suffer from much poorer health", and "87% of the world's poorest are expected to live in Sub-Saharan Africa in 2030" [13]. These differences in health issues and systems inevitably influence choice of suitable e-health (m-health and non m-health) solutions.

m-Health applications have been successfully applied to all facets of healthcare and medical practice, and m-health has been heralded as a panacea to many healthcare challenges in the developing world [14]. This expectation will not be met unless factors that affect adoption of m-health by patients are systematically investigated and addressed. The aim of this study was to identify those factors that enable or impede the adoption of m-health by patients in the developing world and synthesise them into a practical proposed conceptual framework. The study findings will inform policy and help facilitate the future implementation of m-health in the developing world for patients.

2. Methods

A structured literature search of the PubMed and Scopus databases was conducted during December 2017 and updated in January 2020. The structured approach included: careful selection of keywords and search terms, careful structuring of search strings, multi-person review and selection of located articles, consensus agreement against defined inclusion and exclusion criteria, and abstraction of data from included studies, but no assessment of the quality of included studies was made. For PubMed a consolidated search string combined MeSH terms and All Fields terms for keywords: ("telemedicine"[MeSH Terms] OR "telemedicine"[All Fields] OR "mhealth"[All Fields] OR "cell phones"[MeSH Terms]) AND ("developing countries" [MeSH Terms] OR "Africa"[MeSH Terms] OR "Asia"[MeSH Terms] OR "Latin America"[MeSH Terms]) AND (("Patients" [MeSH Terms]) OR ("barriers"[All Fields]) OR ("barrier"[All Fields]) OR ("challenges"[All Fields]) OR ("facilitators"[All Fields]) OR ("successes"[All Fields]) OR ("obstacles"[All Fields]) OR ("obstacle"[All Fields]) OR ("failure"[All Fields]) OR ("success"[All Fields])). For Scopus an equally consolidated search string was used.

The searches were restricted to articles in English during the period 2000–2019 inclusive and relevant to the developing world. Although commonly used, the debate about the terms 'developing world/developing country' remains [15], therefore the definition inherent to MeSH was accepted ("Countries in the process of change with economic growth, …"). Duplicate articles were removed. Titles and abstracts were screened by all authors, and those studies that met the inclusion criteria, based on consensus, were selected for full-text review. Inclusion criteria were: the resources addressed mobile health or m-health, used cell or mobile phones in the context of patients, and identified factors that facilitate or impede m-health adoption by patients in the developing world. Resources were excluded if they did not specifically address m-health and patients, but addressed telemedicine, telehealth, or e-health more broadly, or were focused on the developed world, healthcare workers, or healthcare organisations. Hand searching was also performed. Final selection of resources was discussed by all three authors, and study inclusion based on consensus. Full text review and subsequent data abstraction was performed by two authors.

Inductive iterative content analysis was used to independently categorise elements, and extract themes from the data. A published approach to content analysis was adopted [16], and no underlying framework for categorisation was used. Two researchers (MAD, RES) independently read and re-read the selected literature resources (study data) to identify factors that the researchers believed were important and might impact a patient's adoption of m-health. This process gave rise to initial groupings. These factors were collated in an Excel database, then iteratively and collaboratively reviewed and agreement reached in further grouping them into distinct categories. These categories dealt with the same or related issue(s) and were assigned a descriptive title. Thereafter, categories were again iteratively and collaboratively appraised, and agreement reached on placing multiple categories into groupings to identify common themes, and each assigned a descriptive title. This process gave rise to a final set of themes and subcategories.

3. Results

The combined searches from PubMed (576), Scopus (326) and hand searches (40) returned 942 resources, of which 54 studies met the study inclusion and exclusion criteria (Fig. 1).

Research methods used in the 54 reviewed resources were: 25 qualitative papers [17–41], nine surveys [42–50], seven mixed methods [51–57], four experimental [52,58–60], three usability assessments [8,61,62], two cohort studies [63,64], and four cross-sectional studies [65–68]. Collectively they reported the spectrum of factors that affect patient adoption. The papers reported a variety of m-health uses, including assisting communication and information management [18,22,24,28,31,33,40,54,61], HIV/AIDs and tuberculosis drug adherence [21,26,27,38,39,44,45,48,50–52,57–60,67–69], maternal health support [8,19,21,25,27,29,41,49,50,62], mental health support [35,43,55,64], and monitoring malaria [47,65]. Data were abstracted, and adoption factors initially summarised and grouped under headings based on 11 common uses of m-health extracted from the results. These data were then separated into specific factors that promoted or impeded patient m-health adoption in the developing world and initially categorised under 22 thematic headings. Continued iterative review reduced these to seven primary categories, with 20 subcategories (Table 1). Exactly why an element was placed in one category versus another inevitably involved some subjectivity. For example, language can be 'personal' (a user characteristic) or 'contextual' (a population characteristic and deserving of distinct identification). Similarly, 'cost' is something an individual incurs (and influences ownership), whereas 'funding' is typically provided or received by institutions and not individuals (often associated with 'collaboration'). In addition, whilst 'infrastructure' (a national issue) was considered to impact but be out of the control of patients, 'cost and ownership' (e.g., of a cellphone, a personal issue) also impacted but was very much within the control of patients. As a consequence they were identified as separate categories, although some might interpret differently. Judging from the frequency with which an issue was addressed, the most influential factors were cost and ownership and user characteristics, with the remainder notably less (but each

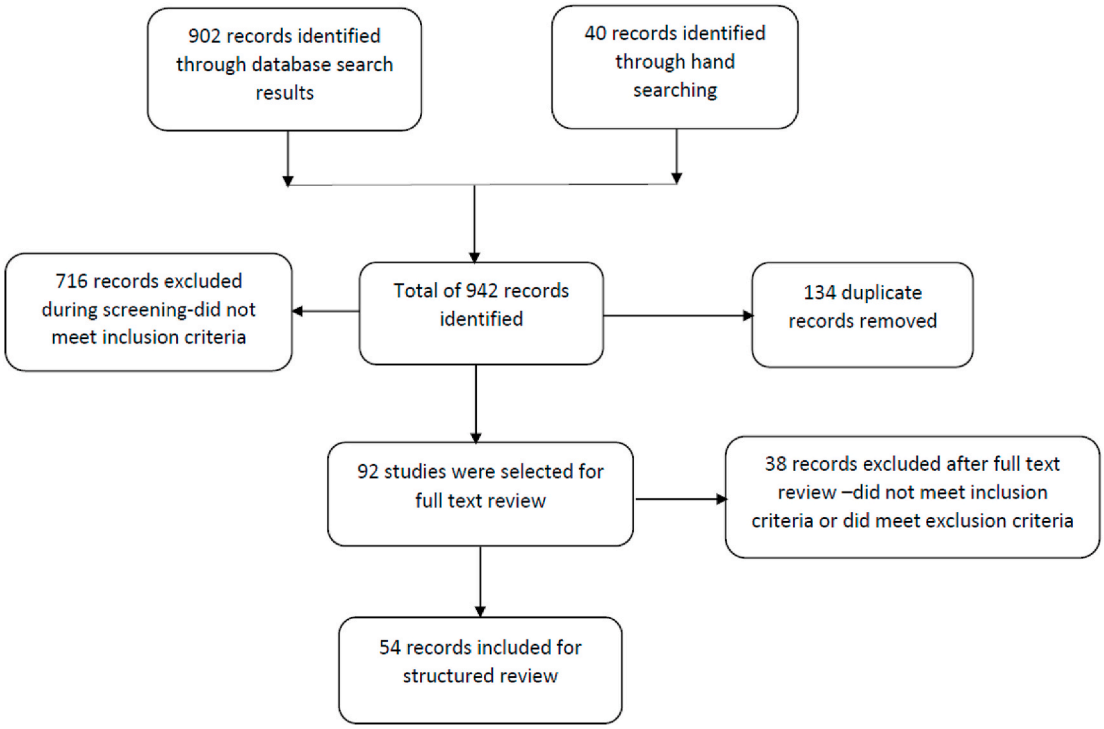

Fig. 1. PRISMA flow diagram showing literature search results.

Table 1
Final grouping of factors impacting patient adoption of m-health in the developing world, sorted by frequency of reporting in the literature.

Category	Subcategory	Frequency
1. Cost and Ownership	1. Cost, affordability, and incentives [17–19,29,43–45,51,60,61,63]. 2. Phone ownership [20,25,44,46–48,58,63,65]. 3. Charging and maintenance [33,36,37,43,53,70]. 4. Access to mobile devices [8,25,37,48].	30
2. User Characteristics	1. Socio-cultural issues, and local context [25,30,37,42,44,62] 2. Acceptability and perception of use, and willingness to use [19–21,24,26,27,42,43,50,65,69]. 3. Health workers competence and readiness to use technology [33,52,59]. 4. Gender and patient age [8,19,21,22,25,28,37,44,53,57,66].	33
3. Language and Literacy	1. Language [22,24,46,66,67,69,71]. 2. Education and training [8,24–26,42,48,49,56,65,66].	17
4. Infrastructure	1. Technology infrastructure [8,18,19,28–31,40,49,50,64,65,67]. 2. Reliable electricity [28].	14
5. Collaboration and Funding	1. Strong Stakeholder collaborations [8,17,21,44]. 2. Government and community ownership [21,25,32,45,52]. 3. Availability of sustainable funding [52,54].	11
6. Governance	1. Regulatory Setting (legality, ethics, and confidentiality) [17,20,21,27,45,51,52,59,63,67]. 2. Data Security Setting (Privacy and Security) [19,28,57,62,72,73].	16
7. System Utility	1. Effectiveness of system [18,21,24,26,38,40,48]. 2. Demonstrating Clear Benefits to Patients [17,32,39,40,52,74]. 3. Evaluation and Monitoring [19,22,25,49].	17

similarly) influential. These are described below.

3.1. Cost and ownership

Cost and ownership issues related to the impact of ownership, use, and maintenance of a mobile device, and included access to mobile devices and their affordability in terms of fixed (purchase) and variable (use) costs to patients. These issues were collated into four subcategories. Some issues were related to cost, affordability, and incentives. When the operating costs are not affordable [17,18,43,44,51,60,61], and patients must buy airtime (i.e., where the patient pays for the calls or messages he/she receives or makes in accessing m-healthcare from the service provider [63]), m-health is likely to fail, unless the patient is able or willing to pay [19,45]. Patients may accept the technology if the cost of owning and operating it is considered acceptable [29,45]. Such challenges can be reduced by introducing financial incentives to mitigate the cost burden on the patient [74]. Overall there was a lack of evidence of the cost-benefit of m-health systems which also challenges their implementation.

Other issues related to actual cell phone ownership, which was identified as a critical determinant in the adoption and uptake of m-health services [44,46,63], included owning the appropriate mobile phone with the required technology [47,58,65]. One study noted that globally, women are 21% less likely to own a mobile phone than men [25]. It was noted that ownership also influenced behaviour, with patients who received m-health services on their own phones considering it more acceptable, compared to those who shared the phone with others [20,21,75].

Another issue was the ability to keep a mobile phone charged and connected, and the associated costs. In many developing countries power was described as irregular with rural areas being most affected [53,70]. Keeping a mobile phone charged was problematic [33,36,43] and it was common to find people paying to charge their phones at street side vendors [33,37]. Likewise, phone maintenance in the event of a fault was an equally important factor that might jeopardise adoption [50,53,76].

Sharing of mobile devices was the primary issue identified under

access to mobile devices. Many projects relied upon shared use of cell phones [19,48,77]. Although the absolute proportion of shared devices varied, for example from 21% [25] to 51.4% [8], it was recognised as a limitation to implementation. Related to cost and ownership was user characteristic issues, described below.

3.2. User characteristics

This category was also commonly reported and addressed the socio-cultural issues, patient perceptions of m-health and willingness to use technology, healthcare workers competence and readiness to use m-health, and gender issues that impact m-health adoption by patients. Of the four subcategories the impact of socio-cultural practices and beliefs, and gender issues were noted in many studies. Information and communications technology use in low-income countries is lower among females [44,78,79] and a 'gatekeeper effect' was noted in several studies with women requiring permission from their parents, husband or partner to use a cellphone [25,30,42]. This was exacerbated by being ashamed to raise issues about women's diseases with their gatekeeper [42] or fear of punishment if they accessed a phone without permission [37]. Other cultural factors impacted cellphone use, with boys - unlike girls - being allowed to be inquisitive and seek out information about sexual matters [30], and restricted use being enforced through fear of "inappropriate" calling with the opposite sex [37]. In Tanzania, men prevented their wives from owning mobile phones because they believed it facilitated sexual unfaithfulness [62].

Studies reported participants from adolescents to the aged, of both genders, and broad levels of education [21,28,37,53,66]. Some studies suggested that age and gender of patients should be considered when implementing m-health systems, with different age groups having preferences for certain multimedia elements [48,66], and women given less priority in male dominated communities [37,42]. Others reported that children, the elderly and the illiterate needed assistance to initiate a service request [28], or appropriate training for them to use the device [80]. Others found all age groups, genders, and education levels functioned well with m-health interventions [8,21].

Men dominated mobile phone use [21,33,44,66,79,81], although this varied by country [37,42]. Reasons included the gatekeeper effect, but also the lack of primary or higher education for women [8,33]. It was suggested that an appropriate age target for minimally educated women to use m-health would be 17–63 years [8,22,25] but in certain parts of the developing world older women were more likely to own and use a mobile phone for m-health than younger women [53], and in South Africa women were the dominant users [37]. Urban women found evening m-health services more convenient and rural women preferred daytime services [19,28,57].

Acceptability and perception of use, and the willingness and ability of patients to use m-health were identified as issues impacting implementation. Services that did not address patients' perceived needs impacted motivation to use the service [42]. Thus m-health solutions were more readily accepted and adopted by patients when they addressed a patient recognised health need [24,42,43], were considered acceptable and useful to them [18,21,27,45], were friendly and easy to use [26,27,50], and used appropriate multimedia modes (selected for effective communication by the target user group, whether text message, audio, video, animation, or pictures [65]). It was noted that audio (voice) accommodated those with low literacy and helped to build trust [19,43,59], while SMS messaging accommodated those with a slightly higher level of literacy [20,21,59,69].

The competence and readiness of healthcare workers to use technology to deliver an m-health solution also impacted patient adoption. Patients expected healthcare workers to respond to any requests in a timely manner [42,77], and to have the requisite competencies to deliver the m-health services [33], highlighting the need for available and efficient training in the use and management of any m-health technology [52].

3.3. Language and literacy

This category, which included specific language issues but also education and training which impacted literacy broadly, were primary issues for successful m-health adoption [66,67,69]. The clinical benefits of conversing with a patient in their mother tongue, whether written or spoken were noted [82,83] and m-health adoption was affected when patients were not confident in communicating in a language they did not normally use or understand [22,61]. It was suggested that the National official language, which generally serves the interest of the majority, should be used in the deployment of m-health systems [46].

To participate in m-health services, patients need to be literate both in the traditional sense (able to read, write, and speak in their mother language), but also in a broader sense (able to understand the technical needs to effectively use a mobile device, and able to understand their health issues and treatment) [24,46]. In poor rural areas where education levels are often lower [42] people may require the assistance of a family or community member to understand the content of a message sent to them [56]. In general m-health requires minimum literacy on the part of patients for its adoption [65], particularly when patients are appropriately trained to apply the technology [8,24–26,48,49,66].

3.4. Infrastructure

The lack of, or insufficient accessibility to, technology infrastructure in the developing world was noted [1,30], particularly the issue of reliable electricity [28]. Unreliable or poor quality infrastructure [1,19,30,40,64,65] leading to mobile network fluctuations [8] or inadequate cellular signal [29], and unresolved technical issues [67] were identified impediments to m-health adoption. Technology infrastructure upgrade may be required before m-health implementation to provide dependable network infrastructure, remote accessibility, and seamless connectivity [18,28,31,49,50].

In addition, m-Health interventions are dependent upon reliable electric power [28], although alternate innovative means such as 'pedal power' and solar power have been used to a modest degree [84,85]. Social networks highlighting m-health services provided effective publicity and promoted implementation [53].

3.5. Collaboration and funding

This category encompassed collaboration amongst stakeholders and the issue of ownership in terms of possessing a sense of reponsibility for ongoing success. m-Health implementation and patient adoption often relied on the fusion of various independent systems and strong stakeholder collaboration [21,77]. Relevant stakeholder institutions needed to be willing to actively collaborate and share resources for success. This required an appropriate institutional setting that promoted such integration [44], where existing communities, healthcare facilities, technology infrastructure, and other service provider platforms were linked to each other in a seamless connectivity [8,21,70]. Collaboration was also necessary to identify and address patients' challenges during implementation [70]. Very clear stakeholder responsibilities were required to avoid conflict and service ambiguity. The required level of integration was made possible when there was an existing institutional framework supporting the exchange backed by a comprehensive policy regime. The need to engage policy makers throughout (from design through to implementation) and ensuring that the system did not run in isolation from similar national or local interventions was critical to adoption [21,54].

As the government of most countries is either the sole or primary provider – or payer – of healthcare services, government facilitation and sponsorship of m-health implementations influenced adoption by patients. Government or private sponsorship (or perception of the same) was crucial for m-health adoption among patients [45]. For some patients, just involvement of government was enough to give the project

some credibility.

Community ownership of m-health programmes affected patient adoption. Mbuagbaw et al. [52] found that strong community involvement driven by advocacy during home and hospital visits, coupled with active engagement with community leaders, was an important element for patients' adoption. Advocacy both at the level of the community and the healthcare provider was crucial for the undecided user to make up her mind [32]. m-Health should be implemented to reflect the local contexts in which it is deployed. There must be an effort at mobilising resources from the community to support the project internally rather than a concentration on external funding sources, if the project is to succeed [52]. There must also be a fusion between the community and the facility-based services for the system to reflect community context and ownership [21,24].

The success of m-health systems depends on securing sustainable funding. Some of this funding will come from external sources and as such may not be reliable. For sustainability there should be mobilisation of community resources as well funding from external (government) sources, and an avoidance of over reliance on less secure external funding [52] (e.g., faith-based organisations and other non-governmental organisations).

There was a high probability of m-health adoption when there was collaboration among relevant governmental and non-governmental agencies, local community organisations, and funding agencies to reduce cost and promote system ownership [54].

3.6. Governance

Governance encompasses all of the processes that wield influence over a social system (country, organisation, village, tribe) through tools such as laws, regulations, or social norms. The patient-related m-health adoption governance issues included legal, regulatory, and ethical issues including data security aspects to maintain the privacy and confidentiality of healthcare information, records and communications [70,86]. Each of these were noted to impact patient adoption of m-health [21,45,59,67].

An enabling regulatory setting requires suitable laws, policies, and a framework that supports m-health adoption by patients. Legal and regulatory challenges to successful m-health adoption were noted [70], requiring appropriate responses using policies, standards, and regulations [86]. The implementation of a regulatory policy must be the responsibility of all stakeholders especially the regulator and the healthcare provider [70].

Maintaining the privacy of data during collection, storage, and sharing for all patient groups was noted as critical for the adoption and sustainability of m-health systems [20,51,59,63,67,76]. Success instilled confidence in patients [17,27,63,87] while failure had a negative impact [52]. Protecting m-health devices against unauthorised access and having effective standard operating procedures was also noted [28].

Some patients wanted all communications sent directly to their personal mobile devices without going through a human intermediary to guarantee confidentiality [62]. Yet where a patient did not own a mobile phone, caregivers had to be contacted to make the information available to the patient; some considered this a breach of confidentiality [57,73], because mobile phone is considered a preferred medium for communicating sensitive issues [72]. Confidentiality concerns were even noted regarding asking for socio-demographic information from patients [45].

3.7. System utility

This final category refers to how useful or beneficial an m-health solution is to patients. Three subcategories were identified: Demonstrating clear benefit to patients, the effectiveness of the system, and evaluation and monitoring.

m-Health systems were found to be more readily adopted when they demonstrated clear benefits to patients [32,52,74]. Successful adoption may be limited if there is a lack of awareness of the benefits to the general public [22]. Some authors identified that new or prospective participants may want to know if evidence exists of the benefits of m-health to patients [88,89]. Patients will adopt services that address their needs and are considered satisfactory [17]. The mobile phone functions that patients viewed as beneficial included automated reminder systems, drug adherence alarms, and appointment reminders from caregivers [39,40].

Patients had to feel comfortable that an m-health system would successfully deliver what they wanted, and avoided adopting an m-health system they were unfamiliar with or for which there was limited evidence of effectiveness [18,24]. Conversely, several papers reported how much patients appreciated and accepted m-health when it met their needs and made them feel valued [21,38,48,90], provided reliable and timely responses that improved quality of life [87], and facilitated two-way communication between the patient and healthcare provider [26]. This phenomenon of leaving the response promptings to the digital awareness of the patients who may have low digital literacy or the benevolence of caregivers was certainly not reliable [40,91].

An oblique observation was that inadequate evaluation and monitoring can adversely impact patient m-health adoption. Adequate evaluation and monitoring to identify technology, socio-cultural, community, and health related needs that might affect adoption if not addressed before scale-up was not always performed during the pilot stage [49,77]. Similarly, the use of inconsistent indicators and poor evaluation methods made cost-effective uptake of m-health in the developing world difficult to prove [49]. Additionally, adoption of m-health services was facilitated through awareness (marketing and publicity of benefits and capabilities) [19,25], and managing expectations to ensure they were realistic [22,87].

3.8. Proposed conceptual framework

Resources identified through the search addressed 'm-health adoption' issues broadly and not '*patient* m-health adoption' issues specifically, requiring patient related issues to be teased out from the identified studies. Based on the findings, it was considered that for m-health to be maximally adopted by patients in the developing world a conceptual framework (a visual aide memoire of key concepts or variables that need to be addressed; Fig. 2) in which all the above identified factors are captured must be proposed to guide the implementation.

4. Discussion

The study has highlighted great inconsistency of approach, tools, and indicators used in published studies that report (directly or indirectly) on factors that impact patient adoption of m-health in the developing world. The study also revealed a plethora of specific factors that differed from study to study, that varied in terms of their impactfulness from setting to setting, and whose relevance was questionable given the marked change in technology over time. After iterative review by the authors this spectrum of specific factors was reduced to seven primary categories, with 20 subcategories. The seven primary categories were used to develop the proposed framework for patient adoption of m-health in the developing world. Development of a framework was chosen as it provides a simplified visual aid that encompasses all the key components and helps to order thoughts and actions of decision-makers when addressing complex issues. Successful adoption of m-health by patients in the developing world will depend on assessing and addressing the factors comprising the framework before attempting to implement m-health initiatives in any specific setting.

The literature showed that certain socio-cultural practices and beliefs can serve as barriers to m-health adoption, requiring the sociocultural context and setting of a community or town to be understood and considered. In addition to sociocultural beliefs is the sometimes high and unrealistic expectations of the capabilities of an m-health system by

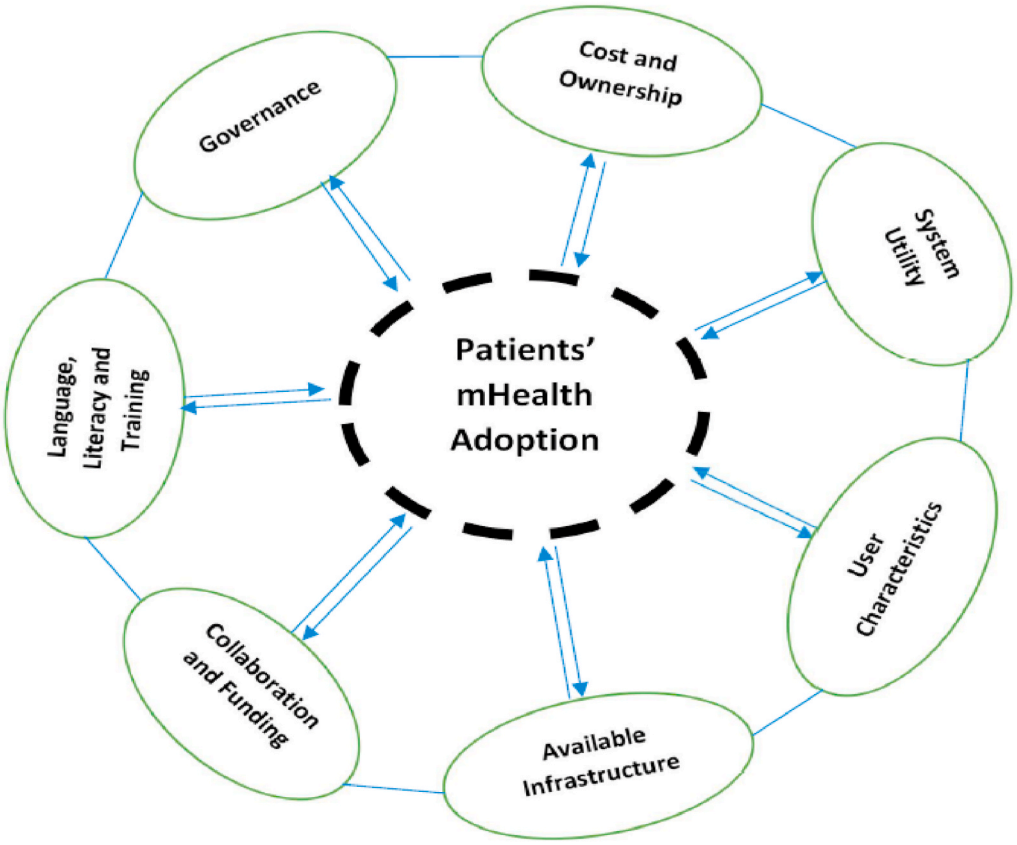

Fig. 2. Proposed conceptual framework for increased patient adoption of m-health by patients in the developing world.

patients, which can also cause it to fail [19]. Consequently, understanding and managing patient expectations is very important to success [18,32]. Some gender factors were identified as location specific. For example, in Ghana and Malawi, males were more likely to own and use mobile phones than females, while the opposite was true in South Africa, a pattern that has persisted over time [37,53].

Poor awareness of m-health was prevalent and impacted adoption. For example, of over 4500 adolescents in Ghana, Malawi and South Africa "only a handful had ever heard of m-health programmes, let alone participated in them" despite using their cellphones creatively and strategically to seek healthcare [53]. Ironically, patients may not adopt m-health if their expectations of m-health capabilities are unrealistic [22,87]. Consequently, efforts to publicise and make patients aware of the benefits and capabilities of an m-health services are necessary [19,25].

Access to mobile devices (and accessories) is considered a precursor to successful m-health implementation [8,62,68], but the basic cell or feature phone ("dumb" phone) still predominates in developing countries [71]. The growing tendency for m-health solutions and services to be smartphone and Internet dependent adds to the cost of ownership. This includes both the base cost for purchase of a suitable device, keeping the battery charged, but then also the cost of participating in m-health services. What is the patient's ability and willingness to afford airtime, SMS messaging, and data use to participate in any m-health services accessed? Corporate and project-based tactics employed to ameliorate these impacts have included reduced or subsidised devices and communication costs that can facilitate m-health uptake and use, but for sustained use by patients this may not be an effective and appropriate approach.

The ubiquity of cellphones was often stated or implied through reporting of high ownership figures. This is perplexing. In the developing world 12.4% of people live on less than USD$ 1.9 purchasing power parity [92]. Furthermore, poverty is associated with an increased burden of disease [69] and low educational levels which reduces income generating capacity thus increasing their likelihood to share mobile devices [44,59,77,79]. To these people ownership of a mobile phone or other mobile device is a luxury and the cost of ownership a stark impediment that may widen the digital divide and impede adoption of m-health solutions and services [41]. Data concerning ownership and use can be confusing and must be interpreted critically. For example, a 2011 International Telecommunication Union report spoke of 6 billion 'subscribers' worldwide. This has frequently been misinterpreted to mean that 6 billion people owned and used mobile phones. What was, in fact, reported was that there were 6 billion active SIM cards in use, with an average of two active SIM cards per subscriber (as of the end of 2019 there were 8.3 billion active SIM cards). Recent reports provide more accurate insight [93,94].

For patients struggling with short battery life for their mobile device, a sustained and accessible power supply is a key consideration to facilitate adoption of m-health. Yet about 1 billion of the global population still live without access to electricity, and about 3 billion still rely on solid fuels and kerosene for cooking and heating [95]. Most without access to reliable electricity live in sub-Saharan Africa where about 6 out of 10 people do not have access to electricity. Even those with access to an electrical grid can face increasingly regular electricity blackouts and brownouts (50–4600 h annually) due to capacity shortages and infrastructure failures, forcing the population to seek alternative sources, often diesel generators [23].

Mobile network service coverage in the developing world differs from country to country, and even within countries urban cities have better penetration compared to rural towns and villages.

There are over 7000 languages in the World and in Africa alone there are over 2000 languages with more than 500 in Nigeria alone [96]. English speakers predominate as users of the www [97] and, as a result,

much of the content remains in English, which poses a concern if patients are to relate to and adopt m-health content. Most people in the developing world will choose their local languages over English for information dissemination because they consider English difficult to understand [55]. The issue of language used by healthcare service providers to communicate to patients, whether written or spoken, can become a barrier to care and m-health adoption when patients are not confident in communicating in its use or understanding [22,61]. It has often been suggested that the National official language, which generally serves the interest of the majority, should be used in the deployment of m-health systems [24,46,65], but this may severely limit the utility of m-health solutions for rural and remote populations in the developing world.

Relevant stakeholder institutions whose services are necessary for effective m-health delivery must collaborate [21,77] based on a predefined inter-institutional framework [44] to effectively address the concerns of patients [70]. This may involve the support from government, private sector, and community leaders. Among these three, government involvement is most crucial since it provides a sense of available funding and system credibility.

There is the need to guarantee the integrity of m-health systems by protecting patients records and communications. Protection of such information is possible in an environment of adequate legal regime and education, and the strict adherence of ethical standards [51,63,70,86].

Based on the review conducted, evidence shows that for m-health to be maximally adopted by patients in the developing world a framework, such as presented in this paper, in which all the factors identified are captured must be used to guide the implementation and promote adoption.

4.1. Limitations

Only two electronic literature databases were used and inclusion was limited to English language resources only, both of which may have limited the scope and frequency of issues found. Most resources were from the peer-reviewed literature, and searching for reports and other grey literature resources may have found additional or complimentary material. As a consequence the proposed framework may not comprise all possible factors that influence patient m-health adoption. Validation of the framework will be required through empirical application.

4.2. Implications

To the authors' knowledge, this is the first study to examine, categorise, and summarise factors that affect adoption of m-health specifically by patients in the developing world. The proposed conceptual framework provides an understanding of the patient's perspective, and the findings can now be used to supplement factors impacting m-health and technology adoption in general by healthcare workers, healthcare organisations, and society, thereby enhancing adoption of m-health overall. Three particular findings are notable. First, a need exists for consideration and assessment, prior to implementation of m-health initiatives, of seven categories of factors that impact adoption of such initiatives by patients in the developing world. Second, given that the spectrum of factors identified was much broader and greater in number than considered in any single study, there is the need for consistent consideration of all of these factors in future studies. Third, noting the variability in impact of any single factor in different settings and for different m-health solutions, it is important to avoid blind transfer of results from one study or setting to another. It is necessary to assess the factors in each setting and for each solution. Such a holistic approach will facilitate and enhance the acceptability and usability of m-health resources by patients in the developing world, and thereby the success and sustainability of such initiatives.

Accepting the above, and in order to achieve increased adoption of m-health by patients in the developing world, it is recommended that:

- Prior to any m-health implementation factors that may impact adoption by patients in a specific setting and for a specific m-health solution must be assessed.
- The assessment must be holistic, considering all appropriate and relevant factors described in the themes and subcategories of the proposed conceptual 'Patient m-health Adoption Framework'
- It must not be assumed that factors impactful to one implementation will be relevant to implementation of a different m-health solution, or the same solution in a different setting.

5. Conclusion

This review shows that the success of m-health project implementation and adoption by patients in the developing world critically depends on addressing key factors identified in the proposed conceptual 'Patient m-Health Adoption Framework'. The framework will serve as the basis for informed decisions by stakeholders (policy makers, implementers, researchers, evaluators) and provide the necessary blue print for future successful m-health implementation in the developing world for patients.

Declarations

Ethics Approval and consent to participate.

This study was approved by Research Ethics Committees of the University of KwaZulu-Natal, South Africa. The study was a literature review.

Consent to publish

Not applicable.

Availability of data and materials

The data generated and analysed during this study are available from the corresponding author on reasonable request.

Authors' contributions

All authors conceptualised the need for and design of the study. MAD contributed to the initial acquisition and interpretation of data, and drafting the first version of the manuscript. All authors participated in the selection of included papers, to further abstraction and analysis of data, and revision of the manuscript. All authors read and approved the final manuscript.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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