Explaining the impact of mHealth on maternal and child health care in low- and middle-income countries: A theory-driven scoping review

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Abstract

Introduction Despite the growing global application of mobile health (mHealth) technology in maternal and child health, the contextual factors and mechanisms by which interventional outcomes are generated have not been subjected to extensive review. In this study, we sought to identify context, mechanisms and outcome elements from implementation and evaluation studies of mHealth interventions to formulate theories or models explicating how mHealth interventions work (or not) both for health care providers and for pregnant women and new mothers.

Method An electronic search of six online databases (Medline, Pubmed, Google Scholar, Scopus, Academic Search Premier and Health Systems Evidence) was performed. Using appropriate MeSH terms and selection procedure, 32 articles were considered for analysis. A theory-driven approach, narrative synthesis, was applied to synthesise the data. Thematic content analysis was used to delineate the elements of the intervention, including its context, actors, mechanism and outcomes. Retroduction was applied to link these elements using a realist evaluation heuristic to form generative theories.

Results Mechanisms that promote the implementation of mHealth by community health workers/health care providers include motivation, perceived skill and knowledge improvement, improved self-efficacy, improved confidence, improved relationship between community health workers and clients, perceived support of community health workers, perceived ease of use and usefulness of mHealth, For pregnant women and new mothers, mechanisms that trigger the uptake of mHealth and use of maternal and child health services included: perceived service satisfaction, perceived knowledge acquisition, support and confidence, improved self-efficacy, encouragement, empowerment and motivation. Information overload was identified as a potential negative mechanism for the uptake of maternal and child health services.

Conclusion The models developed in this study provide a detailed understanding of the implementation and uptake of mHealth interventions and how they improve maternal and child health services in low and middle income countries. These models provide a foundation for the ‘white box’ or theory-driven evaluation of mHealth intervention and can improve the rollout and implementation where required.

Introduction

The potential for mobile health (mHealth) to enhance healthcare utilisation, promote affordability and support accountability in low-and middle-income countries (LMICs) is supported by the near-universal availability of mobile phones, with increasing coverage in many LMICs [1, 2]. There is increasing attention in the use of information and communication technologies (ICT) such as mobile phones to improve the provision and quality of healthcare. In this context, mHealth offers a personalised and interactive tool aimed at promoting healthcare access and awareness [3, 4]. mHealth has the potential to strengthen the public sector for optimal management of chronic conditions and improvement of maternal and child health (MCH) services [5–7]. In addition to promoting health education among patients and reducing

waiting times and cost of healthcare delivery, mHealth enhances patient support, providing a system for emergency response and monitoring [6].

One-way mobile phone messaging is the most common type of mHealth communication used in LMICs [8]. However, the limitation of this approach is that clients only receive messages and cannot interact with health care providers in real-time. Factors influencing mHealth interventions at the individual level include users' intentions, skills, attitudes, perceived norms, self-efficacy, literacy levels and proficiency in the use of mobile devices such as smartphones [8]. Systems-related factors affecting the use of mHealth interventions include unsuitable implementation context, poor internet infrastructure, unreliable power supplies and frequent power outages [9]. Other resource-related factors such as poor internet connectivity and cell phone networks are identified as challenges experienced by health care providers (HCPs) and clients using mHealth interventions.

Systematic reviews support the value of mHealth applications as an effective tool to improve MCH related outcomes as a key step towards achieving the Sustainable Development Goals (SDGs), in particular SDG 3 [7, 10–16]. mHealth has shown to improve health education, facilitate service utilisation, increase clinic attendance, and promote health-seeking behaviour [12, 17]. mHealth also supports regular immunisation and exclusive breastfeeding by targeting behavioural change [7, 18–20].

While outcomes-based evaluation of mHealth interventions can offer insight into their performance, replicating findings across socio-demographic and geographical boundaries becomes challenging because mHealth interventions take different forms. Having a functional understanding of how and why these interventions work (or not) can offer better implementation prospects. This study seeks to respond to this need by exploring and conceptualising contextual elements and mechanisms that interact to explain the observed effects of mHealth interventions on the uptake of MCH services in LMICs. It aims to build a functional theoretical model using realist evaluation principles to explain how, why, for whom, and under which circumstances, mHealth supports MCH services in LMICs [21].

Materials And Methods

Methodological approach

Our study was informed by the realist understanding of generative causality as conceptualised by Pawson and Tilley [22]. They proposed the formula mechanism (M) (resource + reasoning) + Context (C) = Outcome (O), to express the relationship between context, mechanism and outcomes to explicate how interventions "cause" behaviour. According to this formula, O is a product of M in a specific C [22]. Following this generative causality approach, theories or models can be formulated, tested, confirmed

and modified using a context-mechanism-outcome configuration (CMOc) [23]. Some implementation scientists have suggested modifications to the CMOc heuristic to improve the explanatory power of the generative causality principle [24, 25]. Marchal et al. [26] and Mukumbang et al. [27] proposed adding "intervention" (I) modalities and relevant "actors" (A) to the CMO configuration based on the fact that an intervention (I) can only work when adopted by actors (A). Based on this modification, the generative understanding postulates that "outcome (O) is produced by a mechanism (M) activated in context (C) through actors (A) when interventions (I) are executed" [21, 28]. Models developed in this study were achieved by formulating Intervention-Context-Actors-Mechanism-Outcome (ICAMO) configurations (**Table 1**).

Table 1: Definition of the concepts represented in the ICAMO heuristic

Study design

We adopted a realist synthesis approach based on a scoping review of the existing literature. The "York framework" proposed by Arksey and O'Malley [29], which includes five stages guided our realist synthesis:

- Research question identification
- Identify important studies relevant to the research question
- Collection of relevant studies to be included
- Information charting
- Summary, and findings of review reporting

Stage 1: Research question identification

The Arksey and O'Malley framework for literature reviews and synthesis advises consideration of all aspects of the research area while developing research questions [29]. The initial scan of literature and expertise of the research team helped to define the research question: 'How, why, for whom, and under which condition does mHealth support MCH services in LMICs?'

Stage 2: Identify important studies to the research question

Six electronic databases (Medline, PubMed, Google Scholar, Scopus, Academic Search Premier and Health Systems Evidence) were searched between June 2008 and December 2018 using the following

Boolean combinations: [“mHealth” AND “maternal health”], [“mobile phone” AND “maternal health” AND “child health”], [“mHealth AND “maternal health services”], [mHealth PRE/15 maternal] and [mHealth PRE/15 maternal AND child AND health]. A total of 813 records were identified.

Stage 3: Collection of relevant studies

The following criteria were considered for inclusion: peer-reviewed, published in English, published between January 2008 and June 2018, studies conducted in LMICs, studies targeting pregnant women, mothers with new babies and healthcare professionals (HCPs), including community health workers (CHWs). We considered cross-sectional, cohort, and case-control studies, experimental, and randomised controlled trials (RCTs).

Non-full text papers, technical reports, special reports, brief communications, presentation of scenarios or training workshops, editorial discussions, non mHealth applications, telemedicine and other eHealth programme applications were excluded. Studies published before 2008 were excluded as mHealth interventions were not common before that time.

From 813 records identified in the database searches, 747 duplicates and non-relevant titles and abstracts were removed. Of the remaining 66 articles, 14 systematic reviews were also excluded. Fifty-two (n=52) full-text articles were screened for potential inclusion, and twenty (n=20) were excluded for various reasons, yielding 32 articles (**Figure 1**).

Figure 1 PRISMA diagram illustrating the study selection process

Stage 4: Information charting

Data were extracted using the following headings: name of authors, years of publication and study setting or country; summary of the study aim (**Additional file 1**).

Stage 5: Summary and findings

The narrative synthesis (NS) approach proposed by Popay et al [30] informed the process of collating, summarizing and reporting results. The NS framework proposes a theory-driven approach to data synthesis and is compatible with the philosophical assumptions guiding theory formulation in realist evaluation [31]. NS relies on the application of various methods of inference making through the use of

words and text [30]. To this end, NS is applied in reviews addressing several questions, with research evidence in the context of studies that strives to inform policy and practice [30]. Four interrelated steps are involved in an NS: (i) Theory development of how interventions work: (ii) development of a preliminary synthesis of results; (iii) exploring associations in the data; (iv) assessment of the rigour of the synthesis.

Step 1. Theory development of how interventions work

According to Arial et al. [32], a thinking framework herein referred to as initial programme theory, is required as a first step to continuously test and revise our understanding of how interventions could improve people's health [33]. This initial programme theory – an assumption on how the programme should work, guides the process of operationalising mechanisms into theories or models at the end of synthesis. **Figure 2** shows a tentative conceptual model developed a priori based on existing literature on mHealth and MCH. This was achieved through abductive thinking – the inventive thinking required to imagine the existence of such mechanisms to 'suggest' the likeliest possible explanation for the set. The model suggests that when HCPs (A) are educated on mHealth interventions and trained on how to use programme resources (I), their perceived support will motivate (M), encourage (M) and improve their self-efficacy (M), in turn improving delivery of MCH services (O). With regards to programme users, the framework proposes that health educational and reminder messages of MCH (I) will sensitise, motivate (M) and encourage (M) pregnant women and mothers (A) to routinely use MCH services, such as emergency obstetrical care, health facility birth (O) and early initiation of antiretroviral therapy for HIV positive women (O).

Figure 2. Initial programme theory of mHealth programmes

Step 2. Development of preliminary synthesis of results

We applied a deductive thematic analysis, to extract the data [34, 35], based on the concepts outlined in the ICAMO heuristic tool [36], and used an inductive approach to code constructs within each of the concepts (see additional file 1). We identified relevant aspects of the intervention (I), context factors (C), mechanisms (M) and outcomes (O) related to the delivery of mHealth programmes for CHWs/HCPs and pregnant women and mothers separately.

Step 3. Exploring associations in the data

The realist evaluation approach [23, 37] informed the process of constructing the explanatory model. Three different methods were employed to establish the associations of the extracted ICAMO elements: retroductive inferencing, counterfactual thinking and configuration mapping. We applied retroductive inferencing to explore and link the elements of the ICAMO heuristic tool. Retroductive inferencing is a mechanism-focused analytical approach used to reconstruct the basic conditions of phenomena, based on available data (abductive reasoning). Counterfactual thinking was applied to argue toward transfactual conditions – the existence of powers, potentials and liabilities which cause the outcomes [34]. We then mapped possible explanations based on the data through the process of configurational mapping – a process of organising and representing knowledge by linking and specifying relationships between variables.

Step 4. Assessment of the rigour of the synthesis

To assess robustness, three different steps were used: First, we applied the TAPUPAS criteria (Table 2), an appraisal tool developed by Pawson et al. [38], to appraise articles for relevance.

Table 2 TAPUPAS criteria

Secondly, a quality assessment was performed for each article using a research evidence appraisal tool [39] (**Additional file 2**). Eight of the 32 articles were of high quality, and 24 were classified as having good or moderate quality. Results from these studies could thus provide relevant and credible information towards challenging or enhancing the initial theory.

Finally, two study authors (EMK and FCM) applied judgmental rationality – the ability to evaluate different positions as being better or worse – to map ICAMO elements using Vensim® software. This was achieved through discursive and iterative consultation among the researchers until consensus was reached.

Results

Thirty-two (32) studies from different geographic areas were identified: sub-Sahara Africa (21), Asia Pacific (10) and Latin America (1), (**Addition file 1**). Following the initial programme theory (**Figure 2**), findings are presented at the user and HCPs levels.

Implementation of mHealth by community health care providers

Table 3 present the elements used to map the HCPs ICAMO in **Figure 3**, which shows an explanatory model of how and why HCPs implement mHealth interventions appropriately (or/not).

Table 3: Thematic representation of the element of health care professionals

Figure 3*:* Configuration model on how and why mHealth works for health care providers

The first aspect of mHealth interventions is that it offers a communication platform for health education between HCPs and users (I) [40–47]. This is influenced by their experience with technology, level of education, organisation of the health system and availability of resources, including internet infrastructure (C). Having a functional communication platform motivates (M+) HCPs and improves the relationship between HCPs and clients (M+), in turn resulting in improved performance of health services (O+) [41, 48]. The communication platform also improves perceived support of HCPs in the community (M+), improves perceived ease of use and usefulness of mHealth (M+), which increases the quality of MCH service delivery (O+). Having a reliable platform also enhances communication between HCPs and users, which enhances confidence (M+) in providing antenatal and postnatal care (ANC/PNC) services, data collection and improves HCPs performance of health services (O+) [4].

The second relevant aspect of mHealth interventions relates to their ability to offer a data collection, data security and management platform within the system (I) [19, 47, 49–51]. The importance of data collection, data security and management is influenced by the organisation of the health system, HCPs' training, supervision, support and mobilisation, availability of HCPs in the community, and availability of resources (C) [47, 49]. Having a functional data collection, data security and management platform improve knowledge acquisition, confidence and self-efficacy (M+) of HCPs, leading to improved skills and provision of MCH services or improve HCPs' performance (O+) [47, 49, 50]. Knowledge gained by HCPs instils confidence (M+), which results in improved skills ANC/PNC (O+) and data collection (O+).

Another important aspect of mHealth interventions is that these offer an environment of decision-making support and guidelines for HCPs (I) [48, 52–55]. Decision-making support and guidelines properties of interventions are influenced by HCPs' experience with technology and levels of education, organisation of the health system and availability of internet infrastructure (C). Having decision-making support systems and guideline tools in the health system motivates HCPs (M+), thus improving the performance of MCH services (O+) [48]. Improved knowledge (M+) and self-efficacy (M+) offered by decision support and guideline tools result in improved accuracy in diagnosis, referral and recommendations (O+), which also improves the confidence of HCPs (M+) and hence, improvement of quality of MCH services (O+) [54, 55].

Uptake and outcomes of mHealth for pregnant women and mothers

Table 4 presents the relevant themes used to develop the ICAMO model for pregnant women and mothers while **Figure 4** presents a model illustrating how and why various aspects of mHealth interventions work for pregnant women and mothers.

Table 4: Thematic representation of the element of pregnant women and mothers

Figure 4: Configuration model of how and why mHealth works for pregnant women and mothers

The first important aspect of the uptake of mHealth interventions by pregnant women and mothers is the reminder messages (I) [48, 54, 56–59]. Reminder messages are influenced by socio-cultural norms, technical aspects of mobile phone services, community buy-in, health system organisation, socio-economic status of the individual, and political clout (C). Having reminder message services improves perceived user satisfaction (M+), encouragement (M+) and motivation (M+), resulting in improved health services utilisation (O+) and improved (O+) [48, 54, 56].

mHealth interventions also provide a communication platform for health education (I) for pregnant women and mothers [4, 18, 44, 46, 47, 49, 50, 53, 54, 58–65]. Health education is influenced by socio-cultural norms, technical aspects of mobile phone services, political clout, socioeconomic status, and community buy-in (C). Health education improves perceived service satisfaction (M+) [48, 66], self-efficacy (M+), perceived knowledge, perceived support (M+) and confidence (M+). Health education also empowers users (M+) thereby improving their health-seeking behaviour (O+) [47, 67]. When users are educated about MCH, their capabilities to make healthy choices are enhanced, which motivates (M+) them to seek medical care in time [60]. Nevertheless, perceived information overload (M-) can result in decreased visits to health facilities (O-) [16].

The mHealth intervention also offers a consultation platform with HCPs (I) [19, 43]. Consultation platform with HCPs is influenced by socio-cultural practices, norms, political clout, technical aspects of mobile phone services, community buy-in, and socioeconomic status (C). The consultation platform with HCPs motivates pregnant women and mothers (M+) and improve their health-seeking behaviour (O+) [19, 43].

Discussion

Our realist synthesis unveiled generative models related to the provision and utilisation of mobile technology by HCPs and pregnant women and mothers in LMICs. Our review unveiled three groups of intervention modalities for the use of mHealth to improve MCH services relevant to HCPs: (1) Communication platform for health education between providers and users, and communication between HCPs and the health system; (2) Data collection platform, security and data management; and (3) decision support and guidelines. We found six mechanisms explaining how the implementation of mHealth interventions are achieved by HCPs, including (1) Motivation; (2) Perceived skills improvement and knowledge acquisition (improved self-efficacy); (3) Knowledge gained resulting in HCPs confidence; (4) Improved relationship between HCPs and clients; (5) Perceived support; and (6) Perceived ease of use and usefulness. Our model explained clearly how the intervention activated the mechanism to trigger the outcomes observed.

Abejirinde et al. [51], explained that empowerment of health workers explained the competencies of HCPs and that mHealth empowered HCPs to adopt and use mHealth in contexts where it aligns to their needs, workload, training, and skills [51]. The perceived usefulness and ease of use of mHealth encouraged and empowered HCPs with skills and confidence, perceived usefulness related to design and technical concerns, cost, time, privacy, ease of use, and security issues, risk-benefit assessment, experience with the technology, and contact with others (colleagues and patients) [68].

Our study also identified six mechanisms related to the adoption of mHealth by pregnant women and mothers: (1) Perceived service satisfaction, (2) Improved self-efficacy, (3) Information overload, (4) Encouragement, (5) Empowerment, and (6) Motivation. Azhar and Dhillon also identified perceived usefulness and ease of use, behavioural intent, self-efficacy, social influence, attitude and perceived privacy threat as factors that influenced successful use of mHealth applications for self-care [69]. A systematic review by Aker et al. found that users' perceived platform quality, perceived services satisfaction, perceived quality interaction and outcomes were found to influence users' uptake of mHealth for health care utilisation [70]. They identified other dimensions, such as system reliability, privacy, availability, adaptability, efficiency, assurance, responsiveness, functional and emotional benefits to influence the uptake of mHealth interventions.

How our model compares to relevant frameworks

The Fogg Behaviour Model (FBM) [71] is a psychological model which proposes that for a targeted behaviour to occur, the presence of the following is needed in tandem: Ample motivation, ability and an active trigger [71]. Fogg explained that users with high motivation and abilities are likely to perform the target behaviour. The Fit between Individual, Task and Technology (FITT) framework explains the degree

to which technology's functionality matches task requirements and individuals abilities to use the technology to perform tasks [72]. FITT is influenced by technological characteristics, individual abilities, and task requirements on performance and users' evaluation of technology [72]. The Technology Acceptance Model (TAM) seeks to explain users' adoption or rejection of information technology by focusing on two theoretical constructs: perceived ease of use and usefulness [73]. According to TAM, if potential users believe an application is useful, they may at the same time believe that the system is easy or not easy to use, which makes the performance of benefit of usage outweighed by the effort of using the application [73].

We found that FBM, FITT and TAM identified constructs that could be considered by realists as mechanisms to explain how mHealth interventions work. For instance, the FBM model revealed user motivation as central to explaining how mHealth interventions work. The FITT model highlights the perceived ease of use as the central mechanism explicating how mHealth interventions work. The TAM model reveals perceived ease of use and usefulness as the central ingredients to intervention uptake. While the use of theoretical frameworks in mHealth evaluation has been found beneficial to inform best practices [74], these models are limited in their explanatory power in that they largely ignore the role of contextual elements in triggering the identified mechanisms. Our ICAMO models thus not only identify further mechanisms and relevant contextual elements but also illustrate how the contextual factors could impact on intervention modalities provided by the programme to activate the mechanism that produces the outcomes [75]. In this way, our models do not only provide evidence of how and why mHealth interventions work or not, but also context-linked explanatory theories to inform implementation and rollout of mHealth interventions to ensure the conducive health systems and programmatic conditions that increase the chances of the uptake of the intervention among users.

Strengths and limitations

Understanding the influence of mHealth by focusing on the mechanisms and contextual factors through which outcomes are generated, is relevant because more information can be obtained about why mHealth interventions work or not, and what triggers observed outcomes. Lack of information on how mHealth interventions work may encumber understanding of some challenges, justifications for successful mHealth and limitations.

The main limitation of this review is that only six databases were searched, and that search terms were restricted to LMICs. It also relied on articles published in English, which could have resulted in missing important studies on mHealth interventions for MCH. Most articles did not conceptualise the notions of context and mechanisms as understood in a realist philosophical sense. Thus, the strict identification of

these concepts needed further interpretation by the authors. Published studies on MCH-allied mHealth programmes are growing but have been inadequate in evaluating context and mechanisms by which outcomes are generated. More research is needed to evaluate mHealth using realist methods by comparing higher and LMICs.

Conclusion

This review unearthed theoretical models explicating utilisation of mHealth by HCPs and pregnant women and mothers. The models developed in the study provide a detailed understanding of the uptake of mHealth interventions and how they enhance MCH in LMICs. Our findings suggest that mHealth programmes can shift the pattern of health care utilisation. These can be applied by policymakers to inform implementation strategies for mHealth programmes in LMICs. By making explicit ICAMO configurations that are associated with success and failure of mHealth programmes, policymakers can be informed on how to scale-up mHealth interventions. ICAMO models can yield important insights into potential policy changes that might need to be enacted for mHealth interventions to be successful at scale. These models provide a foundation for the 'white box' or theory-driven evaluation of mHealth interventions and can improve implementation where required.

Abbreviations

ANC/PNC – Antenatal and postnatal care

CHWs – Community Health Workers

CMOc – context-mechanism-outcome configuration

FITT – Fit between Individual, Task and Technology

HCPs – Healthcare providers

LMICs – Lower- and Middle-Income Countries

MCH – Mother and Child Health

mHealth – mobile Health

NS – narrative synthesis

ICAMO – Intervention-Context-Actors-Mechanism-Outcomes

TAM – Technology Acceptance Model

RCT – Randomised controlled trials

SDGs – Sustainable Development Goals

SMS – short messaging services

Declarations

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Availability of data and material

The dataset(s) supporting the conclusions of this article is (are) included within the article (and its additional file(s)).

Competing interest

The authors declare no conflict of interest

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Authors' contributions

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References

[1] Majeed-Ariss R, Hall AG, McDonagh J, et al. Mobile Phone and Tablet Apps to Support Young People's Management of Their Physical Long-Term Conditions: A Systematic Review Protocol. *JMIR Res Protoc* 2015; 4: e40.

[2] Abejirinde IOO, Ilozumba O, Marchal B, et al. Mobile health and the performance of maternal health care workers in low- and middle-income countries: A realist review. *Int J Care Coord* 2018; 21: 73–86.

[3] Akter S, Ray P. mHealth - an Ultimate Platform to Serve the Unserved. *Yearb Med Inform* 2018; 19: 94–100.

[4] Ruton H, Musabyimana A, Gaju E, et al. The impact of an mHealth monitoring system on health care utilization by mothers and children: An evaluation using routine health information in Rwanda. *Health Policy Plan* 2018; 33: 920–927.

[5] Martínez-Pérez B, De La Torre-Díez I, López-Coronado M. Mobile health applications for the most prevalent conditions by the world health organization: Review and analysis. *J Med Internet Res*; 15. Epub ahead of print 2013. DOI: 10.2196/jmir.2600.

[6] Sondaal S, Browne JL, Amoakoh-coleman M, et al. Assessing the Effect of mHealth Interventions in Improving Maternal and Neonatal Care in Low- and Middle-Income Countries : A Systematic Review. *PLoS One* 2016; 11: 1–26.

[7] Feroz A, Perveen S, Aftab W. Role of mHealth applications for improving antenatal and postnatal care in low and middle income countries: A systematic review. *BMC Health Serv Res* 2017; 17: 704.

[8] Mbuthia F, Reid M, Fichardt A. MHealth communication to strengthen postnatal care in rural areas: A systematic review. *BMC Pregnancy Childbirth* 2019; 19: 1–10.

[9] Manyati T. A systematic review of the factors that hinder the scale up of mobile health technologies in antenatal care programmes in sub-Saharan Africa. *African J Sci Technol Innov Dev*. Epub ahead of print 2020. DOI: 10.1080/20421338.2020.1765479.

[10] Amoakoh-Coleman M, Borgstein ABJ, Sondaal SFV, et al. Effectiveness of mHealth interventions targeting health care workers to improve pregnancy outcomes in low- and middle-income countries: A systematic review. *J Med Internet Res*; 18. Epub ahead of print 2016. DOI: 10.2196/jmir.5533.

[11] Chen H, Chai Y, Dong L, et al. Effectiveness and appropriateness of mhealth interventions for maternal and child health: Systematic review. *J Med Internet Res* 2018; 20: 1–12.

[12] Sondaal SFV, Browne JL, Amoakoh-Coleman M, et al. Assessing the Effect of mHealth Interventions in Improving Maternal and Neonatal Care in Low- and Middle-Income Countries: A Systematic Review. *PLoS One* 2016; 11: e0154664.

[13] Aranda-Jan CB, Mohutsiwa-Dibe N, Loukanova S. Systematic review on what works, what does not work and why of implementation of mobile health (mHealth) projects in Africa. *BMC Public Health* 2014; 14: 188–203.

[14] Premji S. Mobile health in maternal and newborn care: Fuzzy logic. *Int J Environ Res Public Health* 2014; 11: 6494–6503.

[15] World Bank. World Development Report 2016: Digital Dividends, http://www.worldbank.org/en/publication/wdr2016 (2016, accessed 25 January 2018).

[16] Le Blanc D. Towards Integration at Last? The Sustainable Development Goals as a Network of Targets. *Sustain Dev* 2015; 23: 176–187.

[17] Hall CS, Fottrell E, Wilkinson S, et al. Assessing the impact of mHealth interventions in low- and middle-income countries–what has been shown to work? *Glob Health Action* 2014; 7: 25606.

[18] Obasola OI, Mabawonku IM. Women's use of information and communication technology in accessing maternal and child health information in Nigeria. *African J Libr Arch Inf Sci* 2017; 27: 1–15.

[19] Hackett KM, Kazemi M, Sellen DW. Keeping secrets in the cloud: Mobile phones, data security and privacy within the context of pregnancy and childbirth in Tanzania. *Soc Sci Med* 2018; 211: 190–197.

[20] Colaci D, Chaudhri S, Vasan A. mHealth Interventions in Low-Income Countries to Address Maternal Health: A Systematic Review. *Ann Glob Heal* 2016; 82: 922–935.

[21] Kabongo EM, Mukumbang FC, Delobelle P, et al. Understanding the influence of the MomConnect programme on antenatal and postnatal care service utilisation in two South African provinces: A realist evaluation protocol. *BMJ Open* 2019; 9: 1–9.

[22] Mukumbang FC, Van Belle S, Marchal B, et al. Realist evaluation of the antiretroviral treatment adherence club programme in selected primary healthcare facilities in the metropolitan area of Western Cape Province, South Africa: a study protocol. *BMJ Open* 2016; 6: e009977-88.

[23] Pawson R, Tilley N. Realistic evaluation. 2nd ed. London: SAGE Publications; 1997.

[24] Dalkin SM, Greenhalgh J, Jones D, et al. What ' s in a mechanism ? Development of a key concept in realist evaluation. *Implement Sci* 2015; 10: 49.

[25] Mukumbang FC, Marchal B, Belle S Van, et al. A realist approach to eliciting the initial programme theory of the antiretroviral treatment adherence club intervention in the Western Cape Province, South Africa. *BMC Med Res Methodol* 2018; 18: 47.

[26] Marchal B, van Belle S, van Olmen J, Hoerée T, Kegels G. "Is Realist Evaluation Keeping Its Promise? A Review of Published Empirical Studies in the Field of Health Systems Research." *Evaluation; 2012,* 18,2:

192–212. doi:10.1177/1356389012442444.

[27] Mukumbang FC, Van Wyk B, Van Belle S, et al. Unravelling how and why the Antiretroviral Adherence Club Intervention works (or not) in a public health facility: A realist explanatory theory-building case study. *PLoS One* 2019; 14: 1–26.

[28] Mukumbang, Ferdinand C, Brian van Wyk, Sara van Wyk BM. ' At this [adherence] club , we are a family now ': A realist theory-testing case study of the antiretroviral treatment adherence club , South Africa. *South Afr J HIV Med* 2015; 20: 1–14.

[29] Arksey H, O'Malley L. Scoping studies: Towards a methodological framework. *Int J Soc Res Methodol Theory Pract* 2005; 8: 19–32.

[30] Popay J, Roberts H, Sowden A, et al. Guidance on the conduct of narrative synthesis in systematic reviews : A product from the ESRC Methods Programme Guidance on the Conduct of Narrative Synthesis in Systematic Reviews A Product from the ESRC Methods Programme with. Epub ahead of print 2006. DOI: 10.13140/2.1.1018.4643.

[31] Mukumbang FC, Van Belle S, Marchal B, et al. An exploration of group-based HIV/AIDS treatment and care models in Sub-Saharan Africa using a realist evaluation (Intervention-Context-Actor-Mechanism-Outcome) heuristic tool: A systematic review. *Implement Sci* 2017; 12: 107.

[32] Arai L, Britten N, Popay J, et al. Testing methodological developments in the conduct of narrative synthesis: A demonstration review of research on the implementation of smoke alarm interventions. *Evid Policy* 2007; 3: 361–383.

[33] Peters DH. The application of systems thinking in health: why use systems thinking? *Heal Rearch Policy Syst* 2014; 12: 51.

[34] Eastwood JG, Jalaludin BB, Kemp LA. Realist explanatory theory building method for social epidemiology : a protocol for a mixed method multilevel study of neighbourhood context and postnatal depression. *Springer Plus* 2014; 3: 12.

[35] Doi L, Jepson R, Cheyne H. A realist evaluation of an antenatal programme to change drinking behaviour of pregnant women. *Midwifery* 2015; 31: 965–972.

[36] Marchal B, van Belle S, van Olmen J, et al. Is realist evaluation keeping its promise? A review of published empirical studies in the field of health systems research. *Evaluation* 2012; 18: 192–212.

[37] Wong G, Westhorp G, Manzano A, et al. RAMESES II reporting standards for realist evaluations. *BMC Med* 2016; 14: 96–114.

[38] Pawson R, Barnes C, Boaz A, et al. ESRC UK Centre for Evidence Based Policy and Practice: Working Paper 17 Types and quality of social care knowledge Stage one: a classification of types of social care

knowledge The SCIE project. *ESRC UK Cent Evid Based Policy Pract*; 18.

[39] Petticrew M, Roberts H. Wiley InterScience (Online service). Systematic reviews in the social sciences: a practical guide. Oxford: Blackwell Publications; 2006.

[40] Kaewkungwal J, Singhasivanon P, Khamsiriwatchara A, et al. Application of smart phone in ' Better Border Healthcare Program': A module for mother and child care. *BMC Med Inform Decis Mak* 2010; 10: 69–81.

[41] Ngabo F, Nguimfack J, Nwaigwe F, et al. Designing and Implementing an Innovative SMS-based alert system (RapidSMS-MCH) to monitor pregnancy and reduce maternal and child deaths in Rwanda. *Pan Afr Med J* 2012; 13: 15.

[42] Bigna JJR, Jacques J, Noubiap N, et al. Eff ect of mobile phone reminders on follow-up medical care of children exposed to or infected with HIV in Cameroon (MORE CARE): a multicentre, single-blind, factorial, randomised controlled trial. *Lancet Infect Dis* 2014; 14: 600–608.

[43] Ayiasi RM, Atuyambe LM, Kiguli J, et al. Use of mobile phone consultations during home visits by Community Health Workers for maternal and newborn care: Community experiences from Masindi and Kiryandongo districts, Uganda. *BMC Public Health* 2015; 15: 1–14.

[44] Modi D, Gopalan R, Shah S, et al. Development and formative evaluation of an innovative mHealth intervention for improving coverage of community-based maternal, newborn and child health services in rural areas of India. *Glob Health Action* 2015; 8: 26769.

[45] Kaphle S, Chaturvedi S, Chaudhuri I, Krishnan R, Lesh N. Adoption and Usage of mHealth Technology on Quality and Experience of Care Provided by Frontline Workers: Observations From Rural India. *JMIR Mhealth Uhealth*. 2015;3(2):e61. doi:10.2196/mhealth.4047

[46] Tobe RG, Haque SE, Ikegami K, et al. Mobile-health tool to improve maternal and neonatal health care in Bangladesh: A cluster randomized controlled trial. *BMC Pregnancy Childbirth* 2018; 18: 1–7.

[47] Ilozumba O, Dieleman M, Kraamwinkel N, et al. 'I am not telling. the mobile is telling': Factors influencing the outcomes of a community health worker mHealth intervention in India. *PLoS One* 2018; 13: 1–24.

[48] Shiferaw S, Spigt M, Tekie M, et al. The effects of a locally developed mHealth intervention on delivery and postnatal care utilization; A prospective controlled evaluation among health centres in Ethiopia. *PLoS One* 2016; 11: 1–15.

[49] Hackett K, Lafleur C, Nyella P, Ginsburg O, Lou W, Sellen D. Impact of smartphone-assisted prenatal home visits on women's use of facility delivery: Results from a cluster-randomized trial in rural Tanzania. *PLoS One*. 2018;13(6):e0199400. Published 2018 Jun 18. doi:10.1371/journal.pone.0199400

[50] Asiki G, Newton R, Kibirige L, et al. Feasibility of using smartphones by village health workers for pregnancy registration and effectiveness of mobile phone text messages on reduction of homebirths in rural Uganda. *PLoS One* 2018; 13: 1–14.

[51] Abejirinde IOO, Douwes R, Bardají A, et al. Pregnant women's experiences with an integrated diagnostic and decision support device for antenatal care in Ghana. *BMC Pregnancy Childbirth* 2018; 18: 1–11.

[52] Mwendwa P. Assessing the fit of RapidSMS for maternal and new-born health: perspectives of community health workers in rural Rwanda. *Dev Pract* 2016; 26: 38–51.

[53] McNabb M, Chukwu E, Ojo O, et al. Assessment of the quality of antenatal care services provided by health workers using a mobile phone decision support application in northern Nigeria: A pre/post-intervention study. *PLoS One* 2015; 10: 1–12.

[54] Atnafu A, Otto K, Herbst CH. The role of mHealth intervention on maternal and child health service delivery: findings from a randomized controlled field trial in rural Ethiopia. *mHealth* 2017; 3: 39–39.

[55] Martinez B, Ixen EC, Hall-Clifford R, et al. MHealth intervention to improve the continuum of maternal and perinatal care in rural Guatemala: A pragmatic, randomized controlled feasibility trial. *Reprod Health* 2018; 15: 1–12.

[56] Kaewkungwal J, Singhasivanon P, Khamsiriwatchara A, Sawang S, Meankaew P, Wechsart A. Application of smart phone in "Better Border Healthcare Program": a module for mother and child care. *BMC Med Inform Decis Mak*. 2010;10:69. doi:10.1186/1472-6947-10-69

[57] Nie J, Unger JA, Thompson S, et al. Does mobile phone ownership predict better utilization of maternal and newborn health services? A cross-sectional study in Timor-Leste. *BMC Pregnancy Childbirth* 2016; 16: 1–7.

[58] Skinner D, Delobelle P, Pappin M, et al. User assessments and the use of information from MomConnect , a mobile phone text-based information service , by pregnant women and new mothers in South Africa. *BMJ Glob Heal* 2018; 3: e000561.

[59] Bangal VB, Borawake SK, Gavhane SP, et al. Use of mobile phone for improvement in maternal health : a randomized control trial. *Int J Reprod Contraception, Obstet Gynecol* 2017; 6: 5458–5463.

[60] Nyemba-Mudenda M, Chigona W. mHealth outcomes for pregnant mothers in Malawi: a capability perspective. *Inf Technol Dev* 2018; 24: 245–278.

[61] Guerra-Reyes L, Christie VM, Prabhakar A, et al. Postpartum Health Information Seeking Using Mobile Phones: Experiences of Low-Income Mothers. *Matern Child Health J* 2016; 20: 13–21.

[62] Yamin F, Kaewkungwal J, Singhasivanon P, et al. Women's perceptions of using mobile phones for maternal and child health support in Afghanistan: Cross-sectional survey. *J Med Internet Res* 2018; 20: 1–10.

[63] Jennings L, Omoni A, Akerele A, et al. Disparities in mobile phone access and maternal health service utilization in Nigeria: A population-based survey. *Int J Med Inform* 2015; 84: 341–348.

[64] Coleman J, Bohlin KC, Thorson A, et al. Effectiveness of an SMS-based maternal mHealth intervention to improve clinical outcomes of HIV-positive pregnant women. *AIDS Care - Psychol Socio-Medical Asp AIDS/HIV* 2017; 29: 890–897.

[65] Abekah-Nkrumah G, Guerriero M, Purohit P. ICTs and maternal healthcare utilization. Evidence from Ghana. *Int J Soc Econ* 2014; 41: 518–541.

[66] Kazi AM, Carmichael J-L, Hapanna GW, et al. Assessing Mobile Phone Access and Perceptions for Texting-Based mHealth Interventions Among Expectant Mothers and Child Caregivers in Remote Regions of Northern Kenya: A Survey-Based Descriptive Study. *JMIR Public Heal Surveill* 2017; 3: e5.

[67] Feroz A, Rizvi N, Sayani S, et al. Feasibility of mHealth intervention to improve uptake of antenatal and postnatal care services in peri-urban areas of Karachi: a qualitative exploratory study. *J Hosp Manag Heal Policy* 2017; 1: 5–5.

[68] Gagnon MP, Ngangue P, Payne-Gagnon J, et al. M-Health adoption by healthcare professionals: A systematic review. *J Am Med Informatics Assoc* 2016; 23: 212–220.

[69] Azhar FA Bin, Dhillon JS. A systematic review of factors influencing the effective use of mHealth apps for self-care. *2016 3rd Int Conf Comput Inf Sci ICCOINS 2016 - Proc* 2016; 191–196.

[70] Akter S, D'Ambra J, Ray P. User perceived services quality of mHealth Services around the world. *18 th Eur Conf Inf Syst Pretoria, South Africa* 2010; 1–12.

[71] Fogg BJ. Fogg-persuasive behavior. *A Behav Model Persuas Des* 2009; 7.

[72] Goodhue DL, Thompson RL. Task-Technology Fit and Individual Performance. *MIS Q* 1995; 19: 213.

[73] Davis FD. Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Q* 1989; 13: 319.

[74] Bull S, Ezeanochie N. From Foucault to Freire Through Facebook: Toward an Integrated Theory of mHealth. *Heal Educ Behav* 2016; 43: 399–411.

[75] Mukumbang FC, Marchal B, Van Belle S, van Wyk B. Unearthing how, why, for whom and under what health system conditions the antiretroviral treatment adherence club intervention in South Africa

works: A realist theory refining approach. *BMC Health Serv Res*. 2018;18(1):343. doi:10.1186/s12913-018-3150-6.

Tables

Table 1: Definition of the concepts in the ICAMO heuristic

Concepts	Definition/descriptions
Intervention (I)	Refers to the characteristics of various mHealth interventions such as type of technology, co-interventions, and modalities. In this case mHealth modality was defined as use of mobile phones and tablets, making use of text, audio, images, short messaging services (SMS), voice SMS, applications accessible via general packet radio service.
Context (C)	Describes conditions required for programme mechanisms to activate or not. Context can be viewed as circumstances that facilitate or constrain mechanisms, including pre-existing individual, organisational, social and cultural conditions, external to the interventions [75]. In this case context is categorised as: a) Environmental which comprises the broad external environment in which interventions are situated, including political, economic, social, technological, legal, and infrastructural environments [2] b) Organisational/health systems which include resources, policies and structures directly related to the unique health facility settings in which mHealth technology is introduced [2].
Actors (A)	Includes individuals, groups, and institutions that play a role in implementation and uptake of the intervention [76]. In this study actors include pregnant women, mothers, and healthcare providers (HCPs) including community health workers.
Mechanism (M)	A mechanism refers to causal forces, powers, processes or interactions that generate behavioural change. In realist evaluation terms, mechanisms include choices, perceptions, reasoning and decisions that people make as a result of the resources provided by programmes.
Outcomes (O)	Defined as product of mechanisms activated within specific contexts. Outcomes are the anticipated and unanticipated (emergent) consequences of interventions [23].

Table 2: TAPUPAS criteria

Criteria	Guiding question
Transparency	Is it to scrutiny?
Accuracy	Is it well grounded?
Purposive	Is it fit for purpose?
Utility	Is it fit for use?
Propriety	Is it legal and ethical?
Accessibility	Is it intelligible?
Specificity	Does it meet source-specific standards?

Table 3: Thematic representation of the element of health care professionals

Variables	Themes
Intervention	§ Communication platform (information and education). § Data collection platform and management. § Decision support and guideline
Context	**Organisation of the health system** § HCPs training, supervision, support and mobilisation § Resource availability § Availability of HCPs **Experience with technology and level of education** § HCPs' level of education **Resource related context** § Network connectivity and availability § Availability of internet infrastructure
Actors	§ HCPs
Mechanism	§ Knowledge acquisition § Perceived support § Improve HCP-community relationship
Outcomes	**Improved CHWs/HCPs performance of services** § Improved accuracy in diagnosis, referral and recommendations **Improved quality of health care delivery** § Improved MCH services delivery § Improving skills in providing ANC/PNC services and data collection § Increased quality of collaboration with community members

Table 4: Thematic representation of the element of pregnant women and mothers

Variables	Themes
Intervention	§ Reminder messages § Communication platform (health information and education)
Context	**Political clout** § Governmental support **Socio-cultural practice norms**: § Community buy-in § Health literacy **Technical aspect of mobile phone** § Access to working phone § Network availability and connectivity § Lack of trust in the technology and face-to-face preference **Health system aspect** § Awareness of intervention
Actors	§ Pregnant women and mothers
Mechanism	**Perceived services satisfaction** § Sensitisation § Perceived support and confidence § Information overload § Encouragement § Empowerment § Motivation
Outcomes	**Improved overall health seeking behaviour** § Improved use of ANC and PNC § Improved facility delivery and emergency obstetrical care § Increased use of iron tablets and immunization § Improve initiation of pregnant HIV-positive women on antiretroviral therapy **Decreased visits to health care facilities based on perceived sensitisation**

Figures

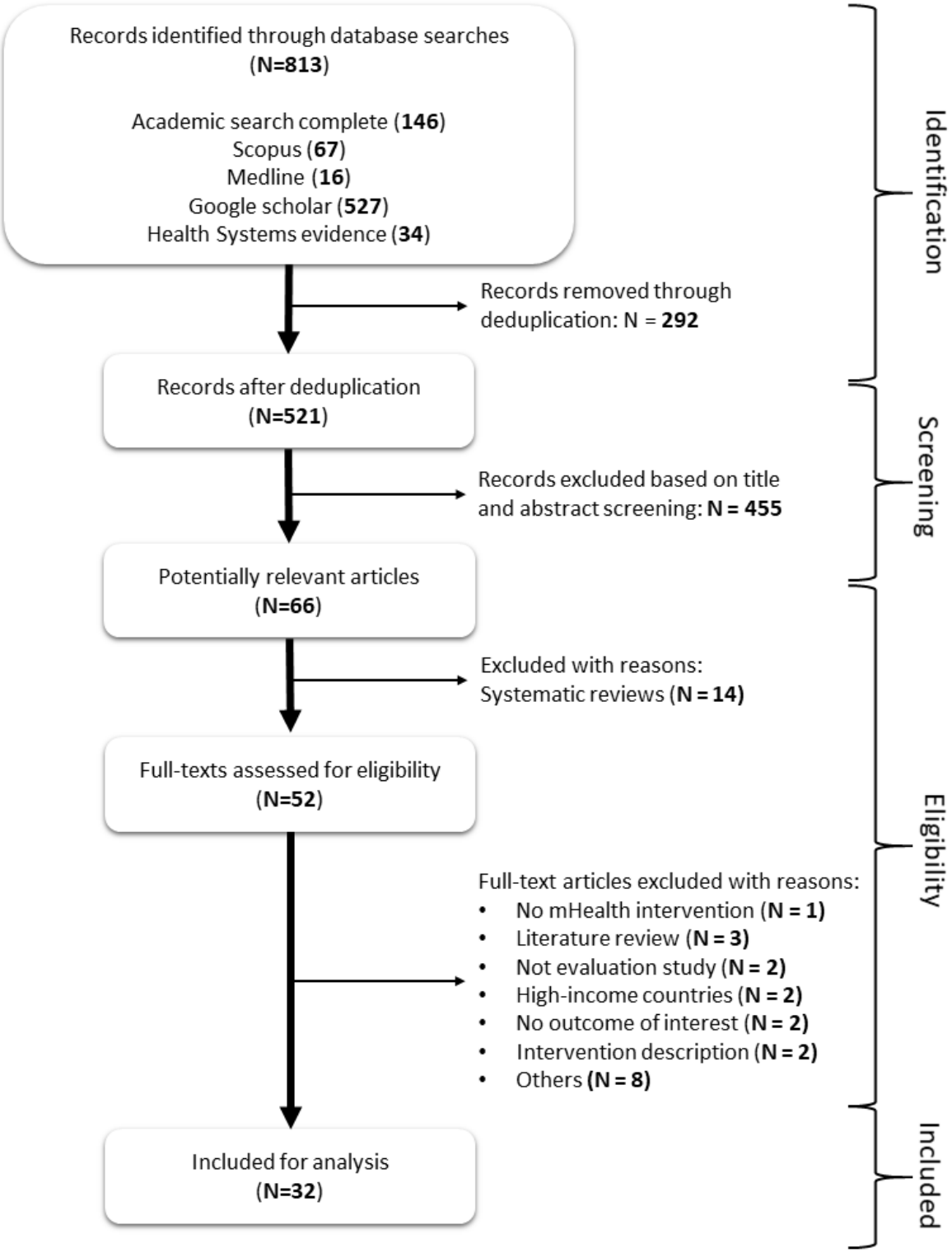

Figure 1

PRISMA diagram illustrating the study selection process

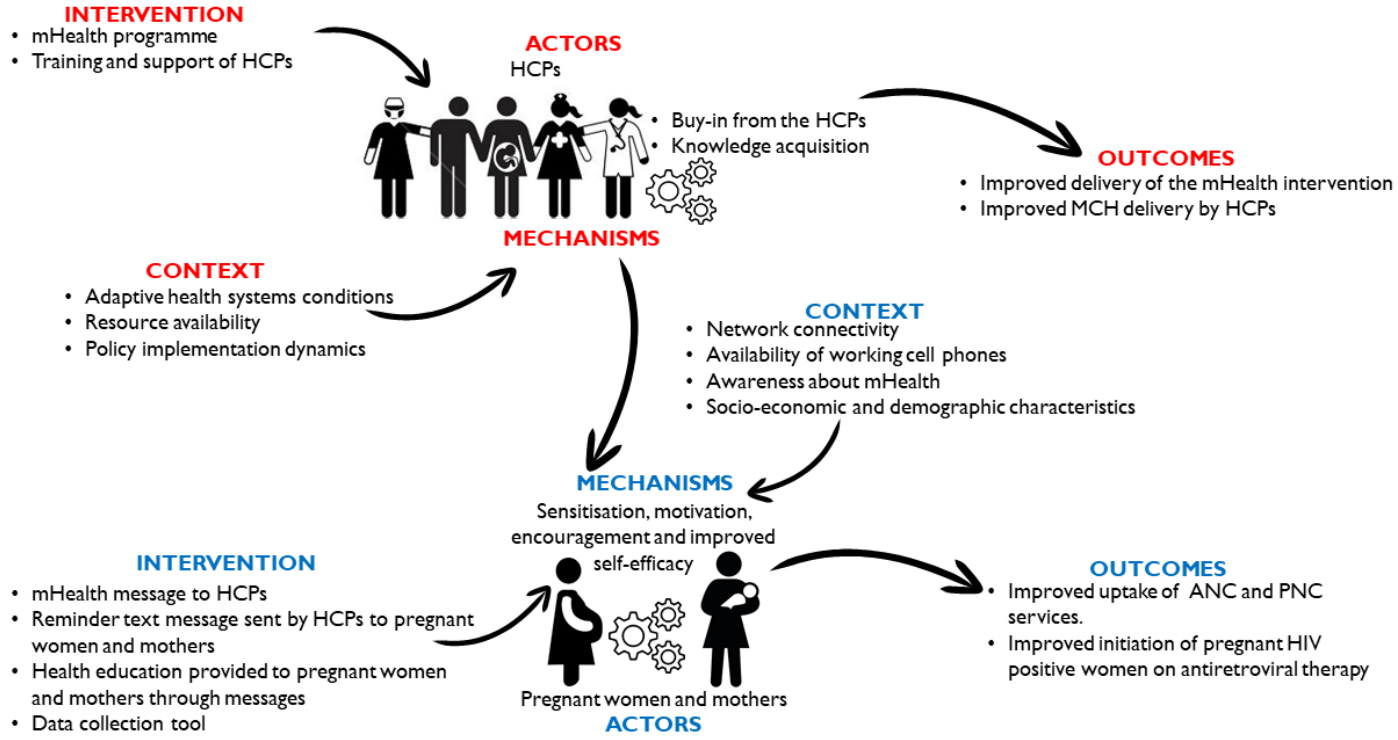

Figure 2

Initial programme theory of mHealth programmes

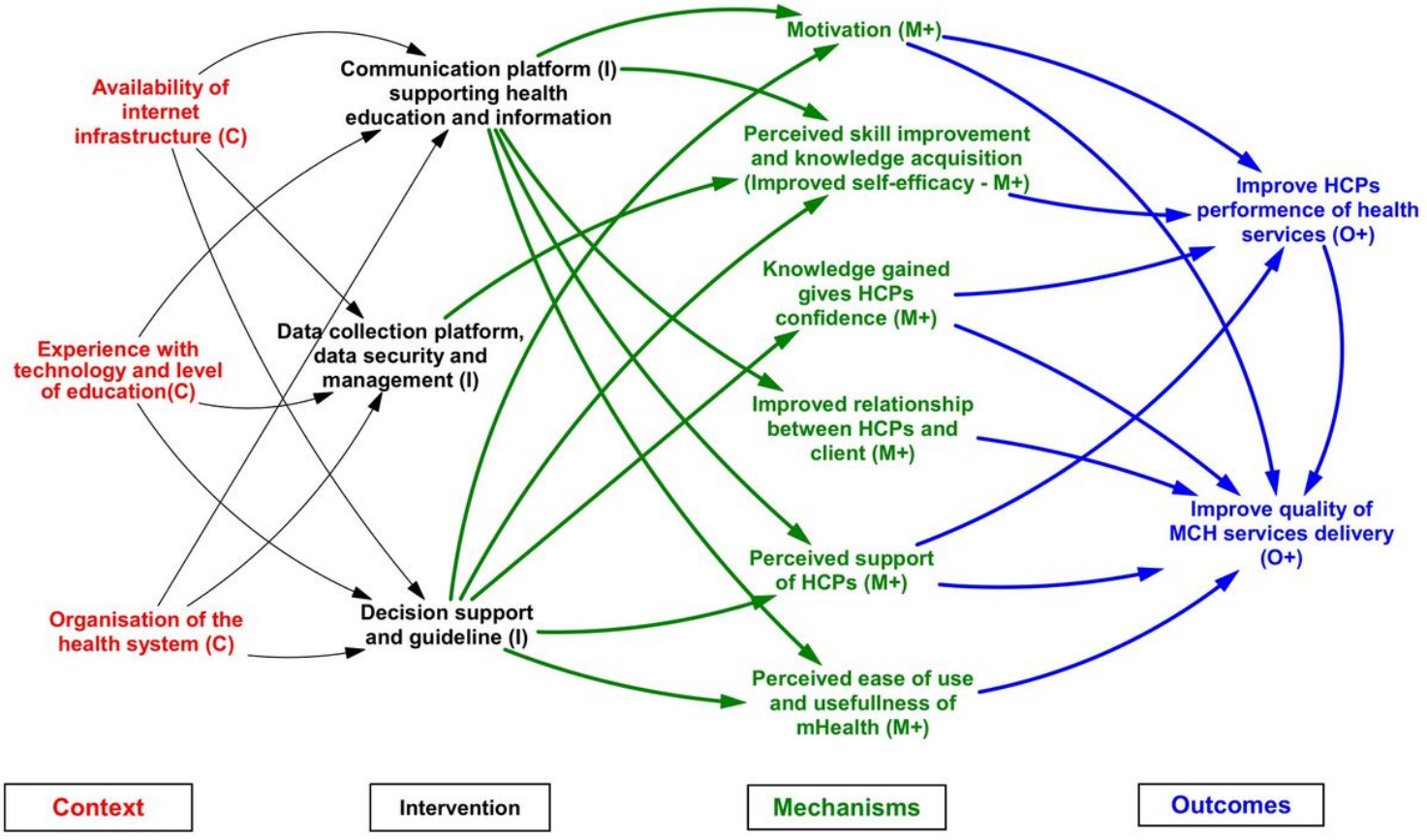

Figure 3

Configuration model on how and why mHealth works for health care providers

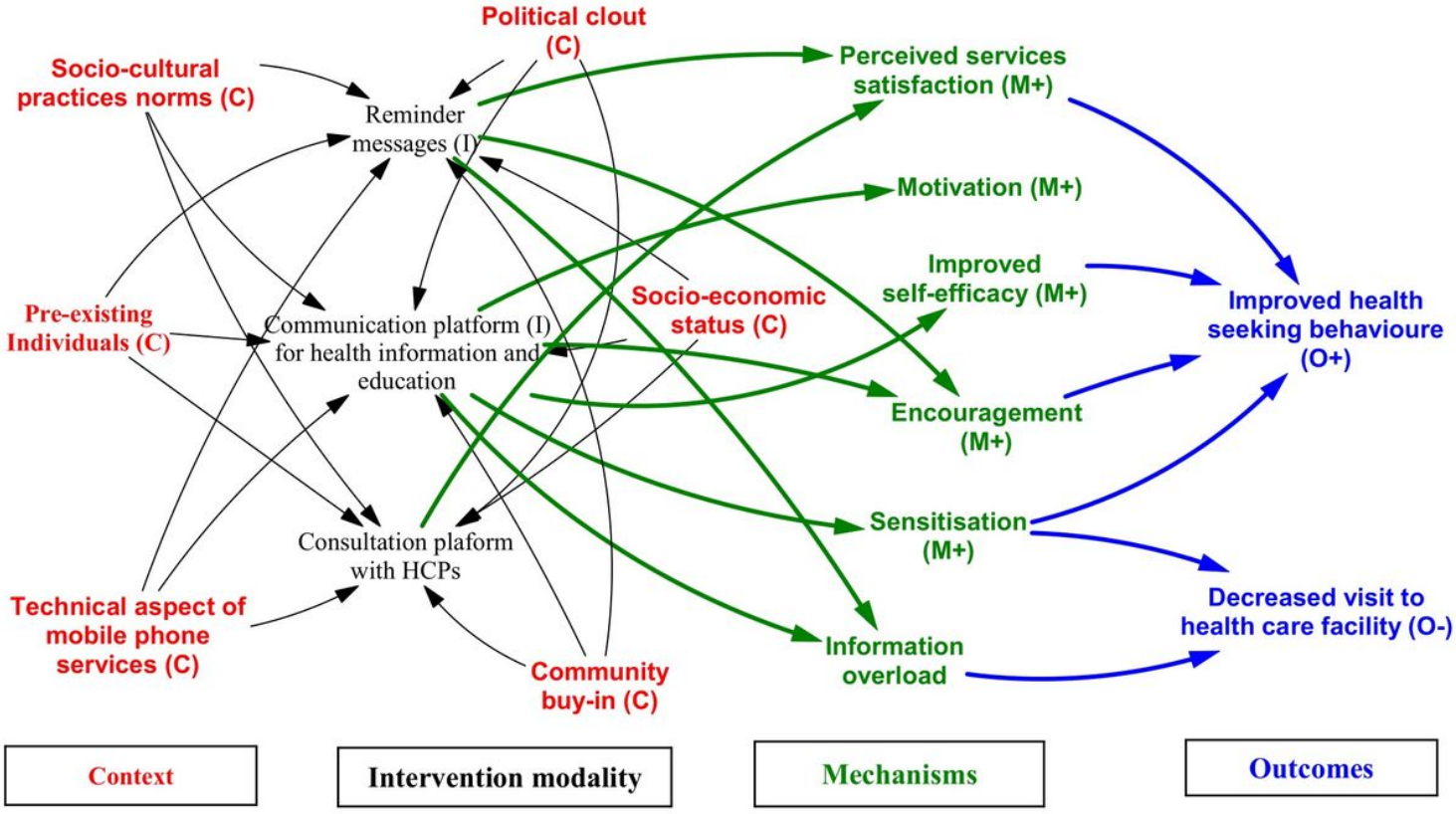

Figure 4

Configuration model of how and why mHealth works for pregnant women and mothers

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Additionalfile3.docx
- Additionalfile21.docx
- Additionalfile11.docx
- PRISMA2009checklist.docx