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.

Contribution To The Literature

- Many studies have shown the relevant of mHealth to improve healthcare services in the health system. This study provides a theory-driven explanation of how, why for whom and under what health system conditions the mHealth programme works and can be scaled up.
- Our study provide an explicit theory-driven model that could a white box or theory-driven evaluation of mHealth interventions.
- We also compared our explanatory model to other existing models in the implementation sciences field.
- The evidence from this study can be used by decisions makers to inform innovations around the implementation of mHealth programme.

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 developing countries [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 services. 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 service delivery, mHealth enhances patient support, providing a system for emergency response and monitoring [6].

Systematic review findings 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), SDG 3 in particular [7–14]. mHealth has shown to improve health education, facilitate service utilisation, increase clinic attendance, and promote health-seeking behaviours [10, 15]. mHealth also supports regular immunisation and exclusive breastfeeding by targeting behaviour change [7, 16–18]. mHealth interventions, however, take different forms, which complicates the ability of programme implementers to replicate findings across socio-demographic and geographical boundaries.

While outcomes-based evaluation of mHealth interventions can offer insight into their performance, little is known about how and why these interventions work (or not). There remains a need to improve the access to primary healthcare services among pregnant women and mothers and hence the need to understand how different contextual factors, such as culture, influence the uptake of mHealth services. This theory-driven scoping review sought to respond to this need by exploring and conceptualising contextual elements and mechanisms that interact to explain the observed effects of mHealth intervention on the uptake of MCH services in LMICs. It aims to build a plausible theoretical model using realist evaluation principles to explain how, why, for whom, and under which circumstances, mHealth supports MCH services in LMICs [19].

Materials And Methods

Methodological approach

Our review was informed by the realist understanding of generative causality as conceptualised by Pawson and Tilley [20]. They proposed the formula M (resource) + C→M (reasoning) = O, to express the relationship between context, mechanism and outcomes to explicate how an intervention “causes” a behaviour. According to this formula “an outcome (O) is a product of mechanism (M) in a specific context (C)” [20]. Following this generative causality approach, theories or models can be formulated, tested, confirmed and/or modified using a context-mechanism-outcome configuration (CMOc) [21]. Some

implementation scientists have suggested modifications to the CMOc heuristic to improve the explanatory power of the generative causality principle [22, 23]. Marchal et al. [24] and Mukumbang et al. [25] proposed adding “intervention” (I) and “actors” (A) components to the configuration based on the fact that an intervention (I) can only work when adopted by actors (A). Based on this modification, the generate understanding postulates that “an outcome (O) is produced by a mechanism (M) activated in context (C) through an actor (A) when an intervention (I) is executed” [19, 26]. Developing the models in this study was 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

The scoping review was informed by the “York framework” proposed by Arksey and O’Malley [29], which include the following five stages:

i. Research question identification
ii. Identify important studies to the research question
iii. Collection of relevant studies to be included in the review;
iv. Information charting
v. Summary, and finding of review reporting

Stage 1: Research question identification

The Arksey and O’Malley framework [29] advises the consideration of all aspect of research area while developing the research question, [29]. The initial scan of literature and the expertise of the research team helped the defined 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 (Search strategy)

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 MeSH terms 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] (**Figure 1**).

Figure 1 PRISMA diagram illustrating the study selection process

From 813 records identified in the database searches, 747 articles were excluded after duplicates removal and abstract and title screening. Of the remaining articles, 14 systematic reviews were also excluded. Fifty-two (n=52) full-text articles were screened for potential inclusion, and twenty (n=20) records excluded for various reasons (Figure 1), yielding 32 eligible articles.

Stage 3: Collection of relevant studies to be included in the review

The following criteria were considered for studies 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, healthcare professionals, CHWs and/or children. 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 phone applications, telemedicine and other eHealth program application were excluded. Studies published before 2008 were excluded as mHealth interventions were not common before that time.

Stage 4: Information charting

The data was charted using an ICAMO framework as described above (additional file1).

Stage 5: Summary and finding of review reporting

The narrative synthesis (NS) model proposed by Popay et al [30] informed the process of collating, summarising 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 a number of questions, with research evidence in the context of studies that strives to inform policy and practice [30].

Four interrelated steps are involved in the conduction of an NS: (i) Theory development of how the intervention works: (ii) development of a preliminary synthesis of results of included studies; (iii) exploring associations in the data; (iv) assessment of the vigorous of the synthesis.

Step 1. Theory development of how, why and for whom the intervention works

According to Arial et al. [32], a thinking framework viewed as a way of understanding and continuously testing and revising our understanding of how the intervention could improve people's health [33], is required as a first step. This thinking framework guides the process of operationalizing the mechanisms into theories or models at the end of the synthesis process. Figure 2 shows a tentative conceptual model developed a priori. The model suggests that when CHWs/HCPs (A) are educated on the mHealth intervention and trained on how to use the programme resources (I), the perceived support will motivate (M), encourage (M) and improve their self-efficacy (M), in turn improving the delivery of MCH services (O). With regards to programme users, the framework proposes that the health educational and reminder messages of MCH services (I) will inform, motivate (M) and encourage (M) pregnant women and new mothers (A) to routinely use MCH services, such as emergency obstetrical care, delivery in health facilities (O) and early initiation on antiretroviral therapy for HIV positive women (O).

Figure 2. *Tentative programme theory of the mHealth programme (source: study author)*

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 of the framework (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 the mHealth programme for CHWs/HCPs and pregnant women and new mothers separately.

Step 3. Exploring association in the data

The realist evaluation approach [21, 37] informed the process of constructing the explanatory model. We aplied 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 a phenomena, based on the available data (abductive reasoning). Counterfactual thinking was applied to argue toward transfactual conditions – the existence of powers, potentials and liabilities which cause observations [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 the relationship (s) between concepts.

Step 4. Assessment of the vigorous of the synthesis

To assess the robustness of the synthesis, three different steps were used: First, we applied the TAPUPAS criteria (Table 2), an appraisal tool developed by Pawson et al. [38], to appraise the selected article for relevance. Overall, included studies met the cited criteria and were considered relevant for our review.

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. We concluded that results from these studies could provide the relevant and credible information towards developing theories.

Finally, two of the 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.

Results

Of the total 32 studies retrieved from different geographic group including Sub-Sahara Africa twenty-one, Asia Pacific ten and Latin America one was included in this review (addition file 2). In accordance with the initial framework, we presented the findings at users and healthcare providers level of users.

Implementation of mHealth by community health workers/health care providers

Figure 3 shows an explanatory model of how and why CHWs/HCPs implement mHealth intervention appropriately (or/not).

Figure 3*: CHWs/HCPs (A) configuration mapping of mHealth ICAMO*

The first aspect relevant to the delivery of the mHealth intervention is that it offers a communication platform [40–43] between CHWs/HCP and users (I). The relevance of the communication platform is influenced by training, supervision, support, and mobilisation of CHWs/HCPs as well as their experience with the technology, level of education, organisation of the health system and availability of resources, including internet infrastructure (C). Having a functional communication platform motivates (M+) CHWs/HCPs [41, 44], and improves the relationship between CHWs/HCPs and clients (M+), in turn resulting in improved MCH services delivery (O+). The communication platform also improves perceived support of CHWs (M+), which increases the quality of collaboration with community members (O+).

The second relevant aspect to the delivery of the mHealth intervention relates to its ability to offer a data collection, data security and management platform within the system (I) [17, 45–48]. The importance of data collection, data security and management is influenced by the organisation of the health system, CHWs' training, supervision, support and mobilisation, availability of CHWs, and availability of resources (C) [45, 46]. Having a functional data collection, data security and management platform improves the knowledge acquisition, confidence and self-efficacy (M+) [45–47] of CHWs/HCPs, leading to improved skills and provision of MCH services delivery (O+). The knowledge gained by CHWs/HCPs instils confidence (M+), which results in improved skills for antenatal and postnatal care (ANC/PNC) services delivery (O+) and data collection (O+).

Another important aspect relevant to the delivery of mHealth intervention is that it offers an environment of decision-making support and guidelines for CHWs/HCPs (I) [44, 49–52]. The decision-making support and guidelines properties of the intervention are influenced by CHWs/HCPs' experience with technology, levels of education, training and supervision, support and mobilisation (C). Having a decision-making support system and guideline tool in the health system motivates the CHWs/HCPs (M+)[44], thus improving MCH services delivery (O+). Improved knowledge (M+) and self-efficacy (M+) offered by decision support and guideline tools results in improved accuracy in diagnosis, referral and recommendations (O+), which also improves confidence of CHWs/HCPs (M+) and hence, improvement of MCH services delivery (O+) [51, 52].

Importantly, the mHealth intervention offers a health education platform (I) to CHWs/HCPs [4, 45, 53–57]. A relevant health education platform is determined by three groups of contextual factors, including experience with technology and level of education; training, supervision, support, and mobilisation; and availability of resources (C). Having a reliable health education platform enhances the communication among CHWs/HCPs, which improves their knowledge acquisition and confidence (M+) [4] in providing

ANC and PNC services, data collection and increased quality of collaboration with community members (O+).

Uptake and outcomes of mHealth for pregnant women and new mothers

Figure 4 presents a model illustrating how and why various aspects of the mHealth intervention work for pregnant women and new mothers.

Figure 4: *ICAMO model of how and why mHealth work for pregnant women and new mothers*

The first important aspect relevant to the uptake of mHealth interventions by pregnant women and new mothers is the reminder messages (I) [44, 51, 53, 58–60]. Reminder messages are influenced by socio-cultural norms, health literacy, awareness of intervention, lack of trust in technology and face-to-face preference, access to a working mobile phone, technical aspects of mobile phone services, community buy-in, and socio-economic status (C). Having a reminder message services improves perceived user satisfaction (M+) [44] and motivation (M+) [44, 51] resulting in improved health services utilisation (O+) and improved facility delivery (O+). Reminder messages also encourage pregnant women and new mothers (M+) to use health facilities and professional healthcare providers for birth delivery [53] such as the use of skilled birth attendants (O+).

The mHealth intervention also provides health information and education (I) [4, 16, 60–66, 45–47, 50, 51, 54, 57, 59] for pregnant women and new mothers. Health information and education is influenced by socio-cultural practice norms, health literacy, awareness of intervention, lack of trust in technology and face-to-face preference, access to a working mobile phone, and technical aspects of mobile phone services (C). Health information and education improves perceived service satisfaction (M+) [44, 67], self-efficacy (M+)[46], perceived knowledge, perceived support (M+) and confidence (M+) [45, 68]thereby improving health services utilisation, improved use of ANC/PNC services and facility delivery (O+). Health information and education also empower users (M+) resulting in improved health seeking behaviour and increased use of iron tablets and immunisation services (O+). [54, 59, 61] When users are informed and educated about MCH services, their capabilities to make healthy choices is enhanced, which motivates (M+) them to seek medical care on time [61]. Nevertheless, perceived information overload (M-) (16) can result in decreased visits to health care facilities (O-).

The communication platform (I) aspect [16, 41, 43, 61, 67–69] identified as useful tool for providers also applies to users. Socio-cultural practices and norms, health literacy, lack of trust in technology and face-to-face preference, access to a working mobile phone, technical aspects of mobile phone services and community buy-in (C) influenced the efficacy of the platform provided by mHealth. Having a real time communication platform encourages (M+) the use of ANC/PNC services, improves facility delivery and emergency obstetrical care (O+), and increased the use of iron tables and immunization (O+) [41]. Having an open communication platform empowers (M+) and motivates users (M+) and thereby increases their overall health seeking behaviour (O+) [61].

The mHealth intervention also offers a mobile phone consultation with HCPs service (I) [17, 43]. The mobile phone consultation with HCPs is influenced by socio-cultural practices norms, political clout, health literacy, awareness of intervention, lack of trust in technology and face-to-face preference, access to a working mobile phone, technical aspects of mobile phone services, community buy-in, and socio-economic status (C). The mobile phone consultation with HCPs motivates pregnant women and new mothers (M+) to enhance their use of ANC/PNC services (O+), improves facility delivery and emergency obstetric care (O+) and increases the use of iron tablets and immunization (O+) [17, 43].

Discussion

The present study aim to explore how, for whom, and under which conditions, mHealth supports MCH services in LMICs, with the goal of building plausible theoretical models. With data obtained from 32 peer reviewed studies, we formulated realist-informed generative models related to the provision and utilisation of mobile technology by CHWs/HCPs and pregnant women and new mothers in LMICs. These models explicate how, why and under which circumstances mHealth programmes work (or not).

Our review unveiled four groups of intervention modalities for the use of mHealth to improve MCH services delivery relevant to CHWs/HCPs: communication platform between providers and users, and communication between HCP and the health system delivery; data collection data platform, security and data management; decision support and guidelines, and health education. Our results are consistent with those found in a study done by White et al. [70] indicating that mHealth tools such as smartphones and tablets can be used successfully to enhance the quality of data collection and, compliance with treatment protocols among patients. The authors emphasised that even though the acceptability of mHealth is sky-scraping, their application is not common. Seven mechanisms explaining how the implementation of the mHealth intervention are achieved by CHWs/HCPs were established, and included: motivation, perceived skill improvement and knowledge (improved self-efficacy, improved confidence, improved relationship between CHWs and client, perceived ease of use and usefulness, and knowledge gained) gives CHWS confidence.

Abejirinde et al. [48], identified usability and empowerment as important mechanisms to explain the adoption of mHealth. The authors explained that empowerment of health workers explained the competence of CHWs and that mHealth empowered CHWs to adopt and use mHealth in contexts where it aligns to their needs, workload, training, and skills [48]. The perceived useful and ease of use of mHealth encouraged and empowered HCPs with skills and confidence Gagnon et al. [71] also found 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 (viz management, colleagues, and patients).

Our study also identified seven mechanisms related to the adoption of mHealth by pregnant women and new mothers: perceived service satisfaction, knowledge acquisition, support and confidence, information overload, improved self-efficacy, encouragement, empowerment and motivation. Azhar and Dhillon [72]

also identified perceived usefulness and ease of use, behavioural intent, self-efficacy, social-influence, attitude and perceived privacy threat as factors that influenced the successful use of mHealth applications for self-care. A systematic review done by Aker et al. [73], found that users' perceived platform quality, perceived services satisfaction, perceived quality interaction and outcome were found to influence users' uptake of mHealth for health care services utilisation. Aker et al. [73] identified other dimensions, such as system reliability, privacy, availability, adaptability, efficiency, assurance, responsiveness, functional and emotional benefits to influence the uptake of the mHealth intervention.

How our model compares to relevant frameworks

The use of theoretical frameworks in mHealth evaluation has been found beneficial to formulate best practices in the field [74]. The Fogg Behaviour Model (FBM) [75] is a psychological model which proposes that for a targeted behaviour to occur, they must be the presence of the following at the same time: Ample motivation, ability and an active trigger [75]. Fogg explained that users with high motivation and abilities are likely to perform the target behaviour. When users have a low ability for instance due to technology requirements, they may find it difficult to complete the task. Users may have a high motivation and ability, but if there is not a trigger (a trigger can take many forms such text messages, an announcement etc.) users will not achieve their target behaviour. When a trigger is identified and associated with target behaviour then users are motivated and able to perform the behaviour. The FBM is somewhat in line with the realist notion of generative causality, our realist theory identified motivation as a relevant mechanism for the succeffully implementation of mHealth programme by CHWs/HCPs and improved the uptake of MCH services by pregnant women and new mothers.

Another theory, the behaviour change support system (BCSS), has been used to measure how outcomes are generated and focuses on whether more traditional information systems can be used to persuade, influence, nudge, and coercion individuals into adopting a behaviour [76]. BCSS uses a technology that provides learning automated behaviour change, using a persuasive application to change human attitude or behaviour through the power of software designs [74]. This is similar to our ICAMO configuration, which explained that intervention modalities influenced actors' or users' conception by improving their self-efficacy, confidence and knowledge acquisition, satisfaction, motivation, encouragement and empowerment. Well-designed messages and a health education and communication platform are designed to give users persuasive information that could influence the way they would react towards MCH services utilisation.

Our ICAMO based theory aligns with the Fit between Individual, Task and Technology (FITT) framework developed by Goodhue and Thompson [77] to explain the degree to which a technology functionality matches task requirements and individuals in performing the portfolio of their work or abilities. FITT is influenced by technology characteristics, individual abilities, and task requirements on performance and users' evaluation of technology [77]. These categories are outlined in our ICAMO configuration which shows that users perceived ease of use –the ability of using the technology, and satisfaction with the technology can produce the desired positive behaviour change. FITT therefore, highlights the influence of

mechanisms such as motivation, which is similar with that found in the model developed in this study that explains mHealth adoption provided a claire knowledge on the role of motivation in the delivery of MCH services.

Another theory from the field of information systems is the Technology Acceptance Model (TAM) developed by David [78] TAM seeks to explain users' adoption or rejection of information technology. David focused on two theoretical constructs, including perceived ease of use and usefulness, which are theorised to be basic determinants of systems use. David showed that attitude impacted the effect of perceived usefulness on intention to use [78]. Whether users adopt or do not adopt an application depend on the extent to which they believe the application will assist their job performance (perceived usefulness). If potential users believed that the application is useful (perceived usefulness), 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 out weighted by the effort of using the application. TAM is in line with the ICAMO configuration model developed in this study, which identified perceived ease of use and usefulness among some other mechanisms that influence behaviour change (delivery and the uptake of MCH services).

Strengths and limitations

The present review provides important insights to understanding how mHealth programmes work, for whom and under which conditions, and motivates the importance of mHealth for addressing MCH service issues in LMICs. Understanding the influence of mHealth by focusing on the mechanisms and contextual factors through which the outcomes are generated is relevant because more information on why mHealth interventions work or not, and what triggers the observed outcomes can be obtained. The lack of information on how mHealth interventions work may encumber the understanding of some challenges, justifications for successful mHealth and limitation. The implication of this study in practice is that it allows a good comprehension of different mechanisms by which MCH services are used and the contextual factors that may affect the implementation of mHealth programmes in different settings.

The main limitation of this review is that only six databases were searched, and that search terms were restricted to LMICs. The review also relied on articles published in English, which could have resulted in missing some studies on mHealth interventions for MCH. Most articles included in the review 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. The published studies on MCH-allied mHealth programme are growing but have been inadequate in evaluating the context and mechanisms by which the outcomes are generated. More research is needed to evaluate mHealth using the realist method by comparing higher and LMICs.

Conclusion

The review unearthed theoretical models explicating the adoption and utilisation of mHealth by CHWs/HCPs and pregnant women and new mothers respectively. The models developed in the study provide a detailed understanding of the implementation and the uptake of mHealth interventions and

how they enhance MCH services in LMICs. Our finding suggests that mHealth programmes can shift the pattern of health care delivery and utilisation. The findings of this study can be apply by policy makers to inform implementation strategies for mHealth programmes in LMICs. By making explicit the types of ICAMO configurations that are associated with success and failure of the mHealth programme, policy makers can be informed on how to scale-up the mHealth intervention. The ICAMO models identified in this study 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 intervention and can improve the rollout and implementation of these interventions where required.

Abbreviations

ANC/PNC – Antenatal and postnatal care

BCSS – Behaviour Change Support System

CHWs – Community Health Workers

CMOc – context-mechanism-outcome configuration

FITT – Fit between Individual, Task and Technology

HCPs – Healthcare providers and

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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Tables

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

Concepts	Definition/descriptions
Intervention (I)	Refers to the characteristics of the various mHealth interventions such as type of technology, cointerventions, and mode of delivery. In this case mHealth modality was defined as the 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 the conditions required for a programme mechanism 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 [27]. In this case context is categorised as: a) Environmental which comprises of the broad external environment in which the intervention is situated, including the political, economic, social, technological, legal, and infrastructural environment [2] b) Organisational/health system which includes resources, policies and structures directly related to the unique health facility settings in which the mHealth technology is introduced [2].
Actors (A)	Includes the individuals, groups, and institutions that play a role in the implementation and uptake of the intervention [28] - In this study actors include pregnant women, mothers, children, healthcare providers (HCPs), and community health workers (CHWs).
Mechanism (M)	A mechanism refers to the causal forces, powers, processes or interactions that generate behaviour change. In realist evaluation terms, mechanisms include the choices, perception, reasoning and decisions that people make as a result of the resources provided by the programme.
Outcomes (O)	Defined as the product of mechanisms activated within a specific context. Outcomes are the anticipated and unanticipated (emergent) consequences of the intervention [21].

Table 2: TAPUPAS criteria

Criteria	Guiding question
Transparency	Is it to scrutiny?
Accuracy	Is it well grounded?
Purposively	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?

Figures

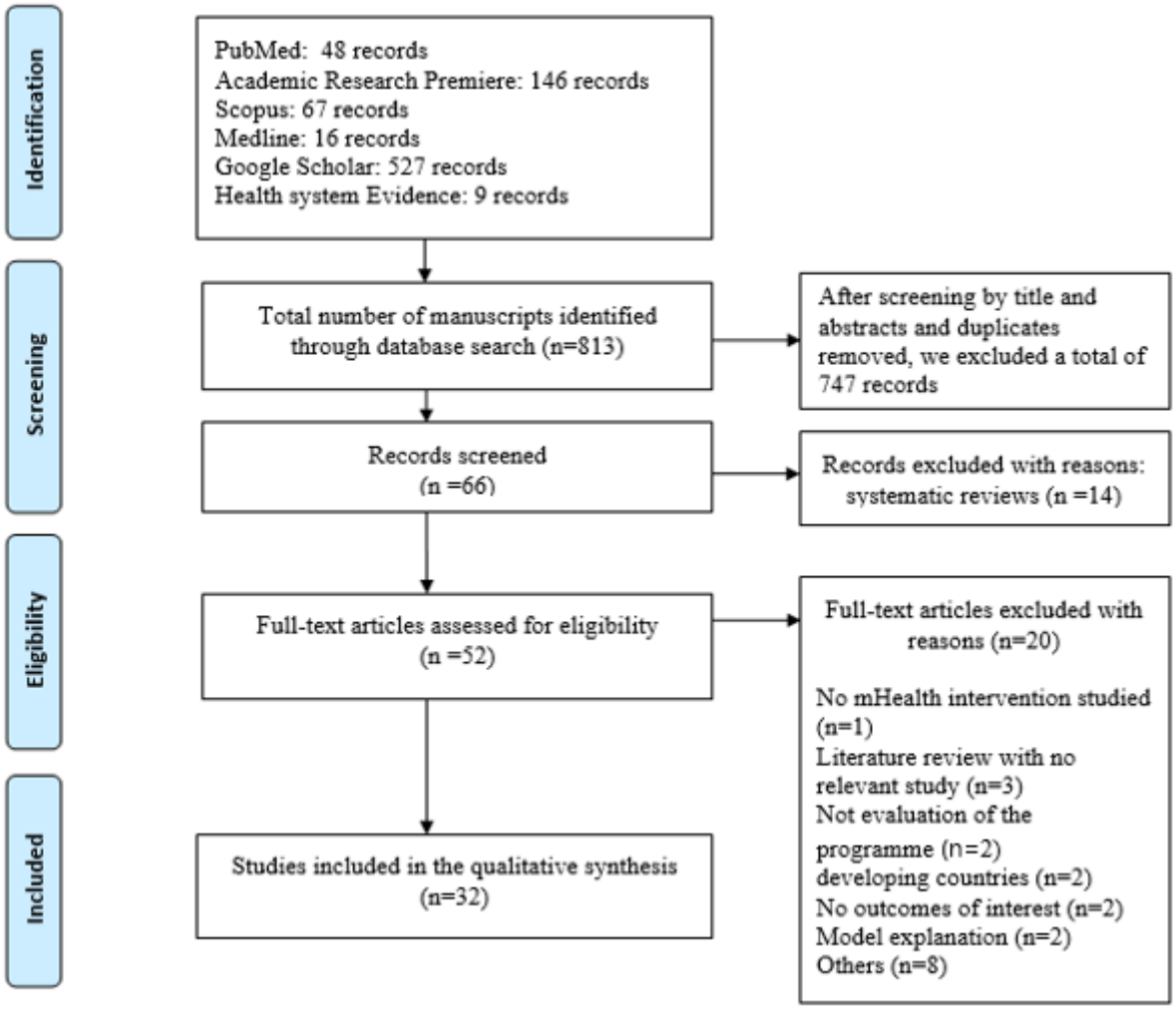

Figure 1

PRISMA diagram illustrating the study selection process

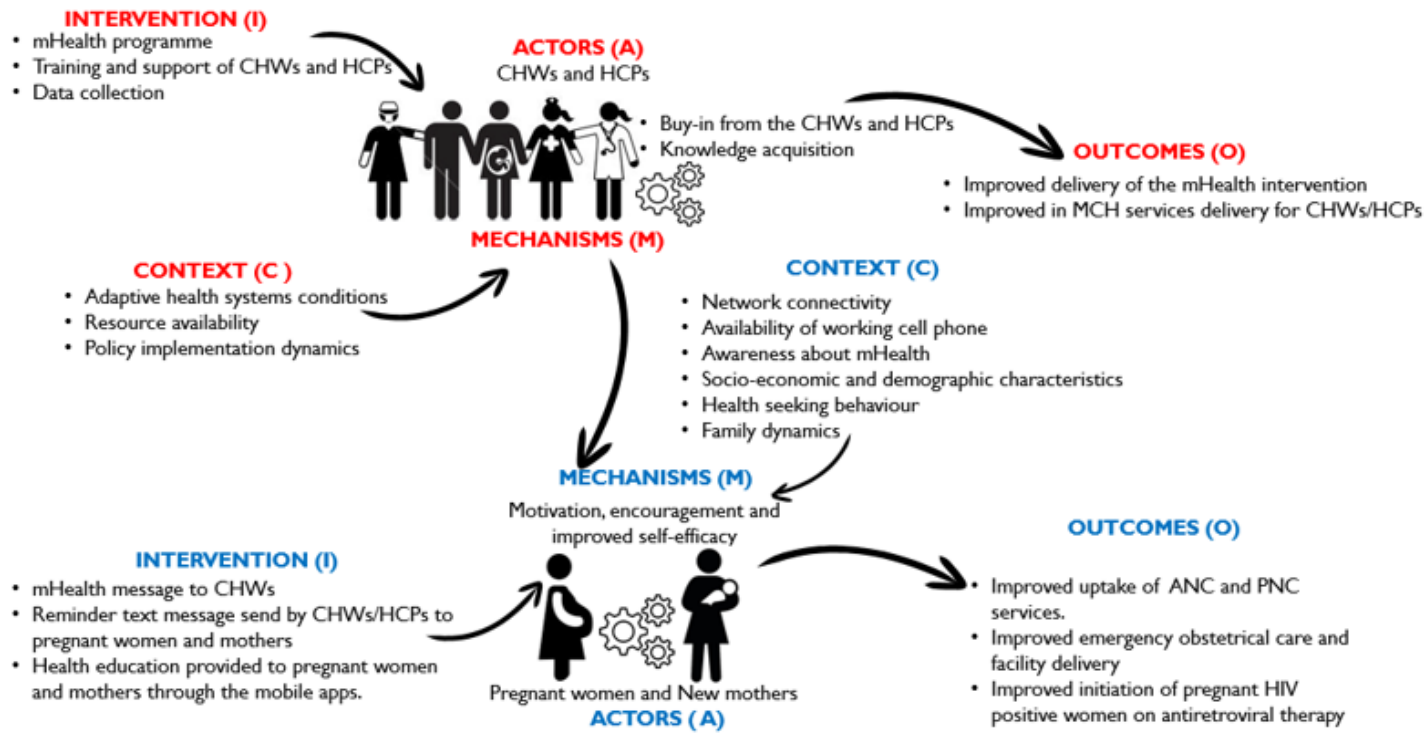

Figure 2

Tentative programme theory of the mHealth programme (source: study author)

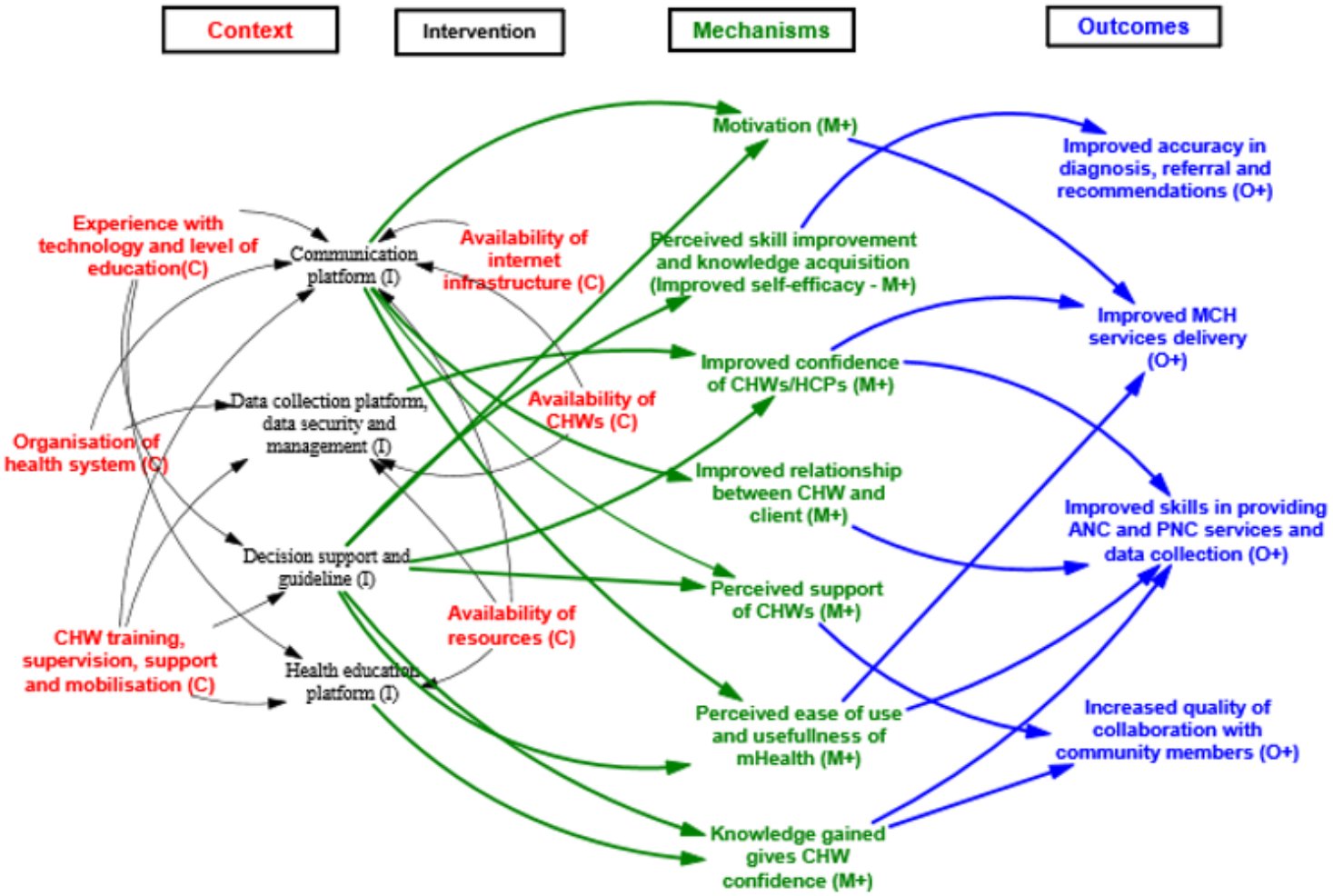

Figure 3

Shows an explanatory model of how and why CHWs/HCPs implement mHealth intervention appropriately (or/not).

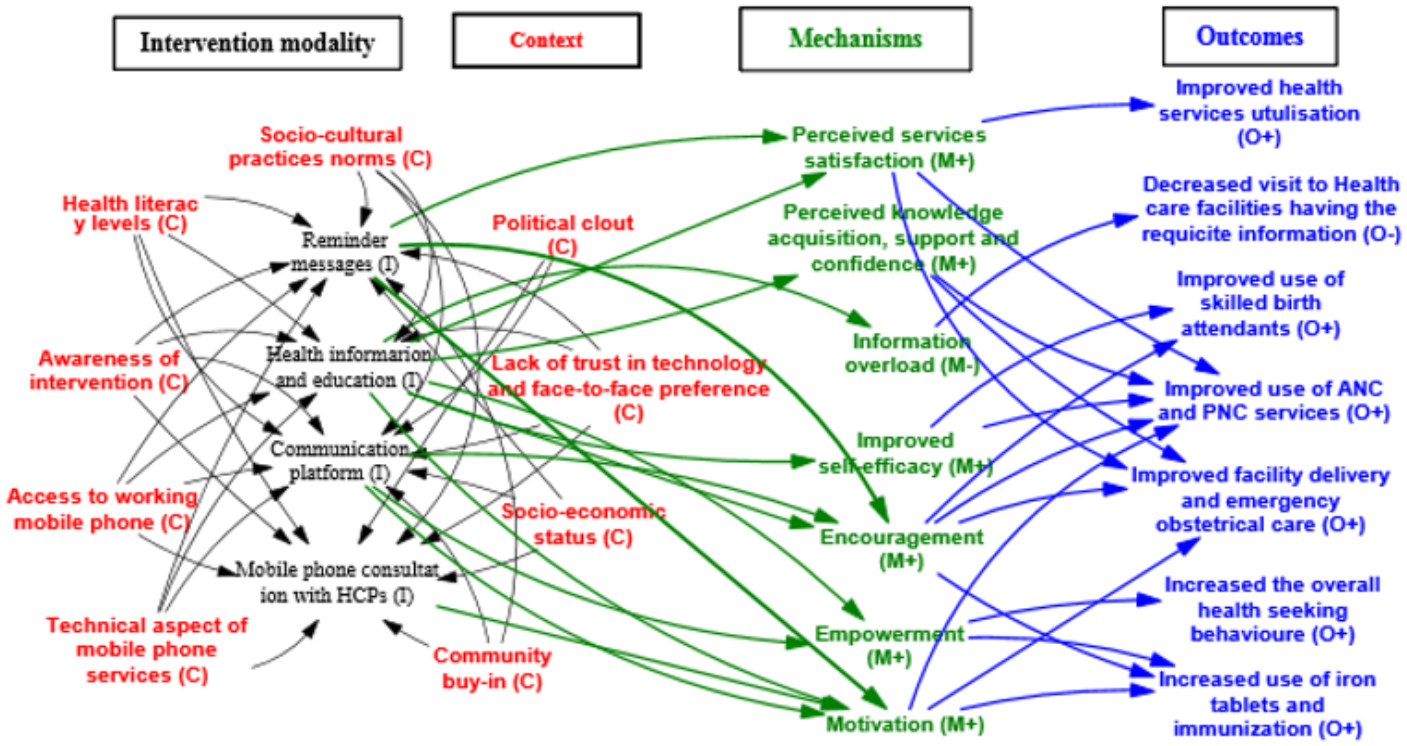

Figure 4

ICAMO model of how and why mHealth work for pregnant women and new mothers

Supplementary Files

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

- Additionalfile3.docx
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- Additionalfile2.docx
- PRISMA2009checklist.docx