

Scaling Mhealth in Africa: Lessons From The Implementation of The MomConnect Program

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Abstract

Background: Mobile health programs have strengthened health systems in Low- and Middle-Income Countries (LMICs) to achieve health-related goals. MomConnect, a mobile health program in South Africa targeted at improving antenatal and maternal health, has scaled rapidly since its creation in 2014. This study explores the barriers and facilitators to the implementation and scaling of the MomConnect program and the applicable lessons for the scaling of mhealth programs in the region.

Methods: We conducted a qualitative study with key project partners and leaders who worked on the MomConnect project. Interviewees were initially identified through a literature review, publications, and evaluations of the project. Interviewees included individuals serving in implementation oversight, champions, partners, funders and frontline implementer roles. The Consolidated Framework for Implementation Research (CFIR) informed the a priori codes for directed content analysis. In total, 15 key stakeholders were interviewed. Interviewees were asked to identify any barriers or facilitators to the implementation of MomConnect and how they would overcome those barriers and strengthen the facilitators.

Results: This qualitative study identified multiple barriers and facilitators to implementation within our domain of CFIR: characteristics of the intervention (complexity, trialability, evidence strength & quality, cost, design quality & packaging, adaptability), inner setting (available resources, compatibility, implementation climate, access to knowledge & information), outer setting (cosmopolitanism, external policy & incentives) and process (planning, external change agents, champions, formally appointed internal implementation leaders). Overarching thematic areas spanning the barriers and facilitators included: (1) strategic partnership and coordination across multiple sectors, (2) innovation costs and funding, (3) operationalization of the innovation to local and national settings and (4) mhealth policy and legislation frameworks.

Conclusion: The barriers and facilitators identified under the CFIR domains can be used to build knowledge on how to strengthen mhealth programs in Africa. The continued success of the MomConnect program will require overcoming identified barriers and capitalizing on known facilitators. These findings can serve as a foundation for the effective design and scale of mhealth interventions in the region.

Contributions To Literature

- This research identifies and analyzes barriers and facilitators for the effective implementation and scaling of MomConnect in South Africa.
- The themes identified from the barriers and facilitators included: partnership relations; innovation costs and funding; operationalization of the innovation; and policy & legislation.
- These findings provided a better understanding of the strengths and limitations of the MomConnect project, and how these lessons can be applied to strengthen mHealth interventions in the region.

Background

The continuous development of health technology has created a great impact on healthcare and research. More specifically there has been a great advancement in mHealth, which can be understood as “medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices” (1). This can involve the use of elements such as short messaging services (SMS), Unstructured Supplementary Service Data (USSD), Mobi, and MXit. The success of mHealth is attributed to its ability to provide public access to healthcare through mobile communication technologies (2). mHealth has played a large role in building open communication and relationships between patients and physicians (3), it has also promoted the delivery of healthcare efficiently and effectively as it is portable. In addition, mHealth has been shown to increase the accessibility of health services and lower healthcare costs (4).

mHealth in Africa today has widely expanded into rural communities due to the integration of mobile networks and reduced costs of mobile devices. Data collected by the World Bank reports mobile cellular subscription rates per 100 people in 2018 to be about 82 persons (82%) (5). Many projects implemented with short messaging service (SMS) applications have been successful. With the strong adoption of mobile phones in Africa, mHealth has become a more effective means of developing services using mobile platforms. South Africa is a leader in the use of mhealth in Africa. There are currently 83 mHealth services in South Africa, with a large focus on HIV/AIDS, women and children (6). A study reports that mHealth adoption in South Africa has deracialized the public health system, providing more accessibility and opportunity of services to all individuals (7). Some of the well-known mHealth projects implemented in South Africa include Project Masiluleke, SIMPill, and the Mobile Alliance Maternal Action (MAMA) project. The MAMA project was a text messaging solution that provided pregnant mothers and their babies with needed support (6). It was launched in 2011 as a public-private partnership, between USAID, Johnson & Johnson, the UN, and BabyCenter.

In 2014, based on the success of the MAMA project, the National Minister of Health launched MomConnect (8). MomConnect is a digital health programme, that was developed to reduce maternal, infant and child mortality and improve maternal health care (9). The program set out to (i) connect mothers to an accessible form of health system through a personalized SMS messaging delivery system; (ii) encourage mothers to attend antenatal visits as soon as they're pregnant; (iii) provide participants with important information on pregnancy and child care (9).

It was scaled with key components such as registration through the USSD system (enrolling every pregnant woman into the national pregnancy registry), weekly text messages, and a two-way communication help desk (10). By December 2017, there has been over 1.7 million pregnant women in 95% of national public health facilities who were receiving health information messages from the program (7).

MomConnect was highly dependent on a variety of stakeholders who contributed value at every stage of the program and also gained value from the program itself (11). For example, through MomConnect

healthcare providers were able to receive feedback from users and improved their services, whereas without MomConnect the healthcare providers would have to invest in and conduct their own feedback surveys (11). In addition, 2 years after MomConnect was launched, NurseConnect was launched in January 2016. This program set out a complimentary program for nurses to provide information they need to successfully run MomConnect. NurseConnect provided SMS text messages and access to a helpdesk, and a mobile website that included information and resources for nurses (12). Delivering the project digitally through SMS text messages was more cost-effective which was of great benefit (13). The MomConnect project was easily scalable because women are just as likely as men to own a mobile phone, and if they did not own a mobile phone, they could use a shared mobile with family members. The project often served as one of the most reliable registries for pregnant mothers. It provided vital health information to new and expectant mothers and families through mobile devices (14).

Several studies have evaluated the MomConnect program (10, 13, 15–19). However, there has been limited acknowledgement of the root causes of the barriers in implementing and scaling MomConnect and limited perspectives provided from those who were involved in implementing and scaling the project. We were therefore interested in understanding how the MomConnect program was implemented and what lessons could be drawn and adapted for other mHealth projects in the region.

The objectives of this study was to provide an assessment of the barriers and facilitators to implementing and scaling of MomConnect from the perspectives of key implementers and partners, and how the barriers and facilitators identified could inform the implementation and scale of other mhealth programs.

Methods

Study purpose and sampling strategy

The purpose of this study was to identify barriers and facilitators to the implementation of the MomConnect program. We did so by interviewing key informants (leadership and partners of the MomConnect project). Interviews were conducted by two of the authors. Key informants were initially identified through a literature review and publications related to MomConnect. We chose to interview current and past practitioners involved in the start, leadership and or evaluation of the MomConnect project. Using snowball sampling, identified key informants recommended additional interviewees. The total number of stakeholders interviewed consisted of 15 key stakeholders, all of whom were selected based on their expertise and experience with the implementation of mHealth interventions, specifically in relation to MomConnect.

Data Collection

Interviews were approximately 25-57 minutes in length and were conducted online using Skype or by phone utilizing a semi-structured questionnaire [see Additional File 1 for interview questionnaire]. The interviews were recorded to be used later to transcribe the interviews. Each interviewee was asked to

describe their role in the intervention. Additionally, they were asked about their knowledge on the current implementation of MomConnect and whether the intervention was difficult or easy to implement. The stakeholders were then asked to identify what they believed were the major barriers to the implementation of MomConnect, and subsequently what would be the most effective way to overcome the barriers mentioned. Lastly, they were asked to denote the major facilitators in the implementation of MomConnect, and what will be the most effective way to strengthen the facilitators mentioned. All 15 interview transcripts were transcribed manually and prepared for next phase of analysis.

Data Analysis

The Consolidated Framework for Implementation Research (CFIR) guided our data analyses and is represented in Figure 1 (20). The interview transcripts were analyzed through manual coding, utilizing ATLAS.ti a qualitative research analysis tool (21). The official 15 transcripts of interviews were uploaded into ATLAS.ti, where each transcript was manually assessed to identify the barriers and facilitators mentioned by key stakeholders. The CFIR framework is a compilation of constructs that are used to evaluate effective implementation (20). This framework consists of 5 domains and 39 constructs as represented in Figure 1. Each barrier and facilitator was coded respectively using this framework. The analyses and coding of the transcripts were done independently by authors 2 and 3. Any discrepancies were discussed with author 1. The data was organized by barrier and facilitator names, along with the coded constructs, domains, and key quotes from the interviews. Based on the data extracted, the frequency of key stakeholders who mentioned certain barriers and facilitators were organized accordingly, as represented in Table 1. The data was then assessed for pertinent themes.

Ethics approval

We obtained Research Ethics Board approval and consent from each participant was received prior to conducting these interviews. Throughout the process, participants were given the opportunity to withdraw voluntarily, at any time, and to pass on questions they were uncertain about or did not want to answer.

Results

From the data extraction and analysis there were 22 barriers and 23 facilitators identified, as represented in Table 2. These barriers and facilitators were grouped into four themes, as represented in Table 3. These themes included partnership relations; innovation costs and funding; operationalization of the innovation; and policy & legislation.

Partnership Relations

Champions

Eleven key informants emphasized that strong political will from the government was a critical factor taking the MomConnect project to scale: *“There was very strong and very senior level government buy in for the Mom Connect project... I have never seen with any health project before” (Int. 12)*. Such leadership

from the government was unique for a mHealth project and was key in scaling among South Africa. Additionally, seven key informants expressed how stakeholders effectively championed the implementation of MomConnect through collaboration, determination, and support from a multi-disciplinary team: *“what made the project so successful was also the collaboration – and was the partners that really did come together, and each had a really unique perspective, and a really focused area of work within the project.”* (Int. 4). Four key informants however expressed the inadequate support from premier principals, operational managers, and CEOs who were involved in launching MomConnect. With such inconsistency in support across the different levels of government and stakeholders there was an impact on how MomConnect was implemented and regulated.

Cosmopolitanism

Five key informants expressed that the management of stakeholders was inadequate in respects to the level of consistency in collaboration and participation in the implementation of the project. They mentioned with the implementation of MomConnect it is difficult to manage the politics and partnerships that exist among the diverse stakeholders. Additionally, there were many stakeholders who had their own objectives which limited program sustainability as they were not all consistently involved: *“challenges for the sustainability of the program because there are a number of different partners involved and all of that is different pieces in the puzzle and if one of those pieces isn’t there, the whole thing doesn’t work. So, ensuring sustainability across the system I think is easier said than done”* (Int. 4).

Formally Appointed Internal Implementation Leaders

One key informant identified in the implementation of MomConnect there was a gap in technical leadership. Acquiring a NDOH technical lead who would understand the technology stacks, was hard because it was expensive. Without a technical lead there was a limited overview on the technology and understanding how the different sets of technology worked to build the applications used in MomConnect.

External Change Agents

Four key informants noted partner relations during the implementation of MomConnect was defined by the different partners and leaders working together and supporting each other: *“Also a very strong leadership particularly in the minister; strong top-down director coupled with simple tech, and relationship amongst the funders, and with HIPPA and NDoH made the project scale quickly”* (Int. 2). Strong partner relations and leadership among donors, Health Insurance Portability and Accountability Act (HIPPA), the minister and NDOH encouraged the project’s successful ability to scale.

Access to Knowledge and Information

Four key informants stated that project practitioners such as nurses had inadequate access to information that the users had access to through MomConnect. Thus, without adequate access to the information users had, nurses felt less inclined to push registration and departments were not effectively communicating with each other. A different key informant expressed that communication among project stakeholders was a challenge as they could not coordinate or maintain regulations.

Innovation costs and funding

Cost

Five key informants expressed that service providers and technology partners greatly supported the program by subsidizing SMS's and messaging to provide a cost-effective adaptation of messaging which benefitted scaling measures. However, nine key informants noted that high cost of data was a large factor that determined accessibility and participation in the program. The same informants mentioned that there is a base cost and linear pricing for SMS costs that limited scaling efforts: *"So trying to keep the cost down of the consumable elements, like the recurring elements; like SMS and USSD segment, keeping cost down on that was not easy and I think there were different factors that played there that made it more difficult to really sustain it"* (Int. 9). Additionally, two key informants expressed there were uncontrollable factors such as market forces that control the costs of SMS, data and access to mobile network signal.

Available Resources

Two key informants noted that many funders were able to establish their commitment to the program by providing the initial funds. This showed how committed the funders were to the project and mHealth in its early phases. Unfortunately, five key informants expressed that there was inadequate training on the use of program technology and program procedure among the project practitioners. They relayed that the level of training was dependent on each facility, it was challenging to keep training consistent and up to date with the high-job turnover rates.

Operationalization of the innovation

Design Quality and Packaging

Ten key informants mentioned that the program greatly benefitted from having technology that is both easy and accessible: *"Everybody has a phone, the software penetration in South Africa is over 100%"* (Int. 13). With the participants' existing familiarity and accessibility with the technology it was easier to implement and scale the program. Three key informants expressed the success of having two-way communication, as it helped assess complaints effectively with direct communication to all levels (clinic, national, district, provincials) and a report that outlined how they fixed the problem. Additionally, MAMA served as an effective guideline for MomConnect, as two key informants noted the MAMA model was adapted to better fit the South African context for MomConnect.

Adaptability

Three informants described the content translation to be easy to access and appropriate which encouraged MomConnect users to participate. The project was also commended by five key informants for the engagement with end-users, as they received a lot of positive feedback that helped effectively scale MomConnect. In respect to language translation, three key informants noted some inconsistencies with translation into the eleven official languages largely due to the cost and ability to manage such a need. They expressed concern about the loss of meaning in translation as many languages were more so spoken than written.

Evidence Strength and Quality

Uniquely two key informants expressed that the program was ready from the beginning to be successfully implemented directly without a pilot phase. The program benefitted from having a strong vision and political support to drive the direct implementation with province wide scaling. Five key informants however expressed that without proper development of a baseline, MomConnect's ability to effectively scale was greatly impacted. The key informants mentioned that the project required baseline evidence to support the government in understanding the program's impact. Additionally, the same informants acknowledged the lack of evidence in MomConnect's implementation was a significant factor that impacted the timeline of the project as they needed to provide proof of efficacy.

External Change Agents

Three key informants discussed how stakeholders' often placed the program implementation under pressure on conducting the program within a certain time period, thus MomConnect was impacted in terms of quality and adoption of the program: *"I think the reason for the pushback from some of the facilities which was due to the time crunch, the Minister of Health wanted and set a date for Mom Connect to be launched. I don't know how he came to that date specifically, but it meant there was very little time for any individual facility level engagement around the Mom Connect project"* (Int. 12). The pressure of time from the Minister of Health, influenced the uptake and engagement of facilities and end users.

Trialability

Two key informants suggested the program was not able to test the intervention and obtain a better understanding of the impact or efficacy of MomConnect before implementation because the program went nationally immediately. As a result, this posed some challenges when scaling and implementing.

Compatibility

Two key informants mentioned that MomConnect was not fully compatible with the health system, as a large number of facilities in South Africa were unable to adopt MomConnect because they felt already stretched for resources, time, or staff it was too much work to add onto their workload. Additionally, two key informants mentioned some participants experienced the inability to register privately or postnatally with MomConnect, due to the switch between sectors they have missed information offered by MomConnect thus far. Although it is now possible for mothers to register for MomConnect postnatally.^[1]

Engaging

Three key informants mentioned that the effective marketing materials and engagement from minister advanced the project promotion and awareness for the MomConnect platform in South Africa. This effective promotion and support from the NDoH among the target population encouraged MomConnect scaling and engaged more participants.

Implementation Climate

Two key informants believed the high literacy rates in South Africa greatly benefitted the implementation of the intervention. These high literacy rates helped adopt the program into the country. However, two key informants expressed that there was pushback from ground-level project implementors of MomConnect. As many of the workers felt the extra tasks in the project to be an added burden.

Policy & legislation

External Policy and Incentives

One key informant highlighted that in the implementation of MomConnect they put the South African Normative Standards Framework into practice. Having such legislative standards made the project run smoother and surpass any technical challenges than a project where this framework was not upheld.

^[1] This information was obtained from personal communication with one of the key informants.

Discussion

This qualitative study identified multiple barriers and facilitators to implementing the MomConnect project. The major emerging themes were those related to intervention characteristics of the MomConnect application, the scaling process, the inner setting and the outer setting of the MomConnect program.

These themes included: partnership relations; innovation costs and funding; operationalization of the innovation; and policy & legislation.

Partnership relations

The theme of partnership relations was identified to be important in respects to the implementation of MomConnect as it impacted the leadership and the overall implementation of the program. The program was greatly supported by the Minister of Health and there was a great amount of political will. The importance of the NDOH involvement and the political support as recognized by two other studies, helped to bring together an interdisciplinary group of partners and effectively develop the program (18,19). Similarly, the importance of political support from the Minister of Health was iterated to be critical in engaging stakeholders and management of the program (19). One important factor this study found that impacted partnership relations was the gap in technical leadership, there was no one to manage and overlook the technical partners. Without this technical lead there was limited understanding and overview between partners, departments, and technology applications. However, one of the critiques suggested by key informants was there was a great amount of burden placed on the ground-level staff as they had additional tasks in an already strict time frame. Additionally, it was also reported that these focal people were often not given the tools to navigate the innovation. Another study also recognized the burden many workers felt when they were introduced to the program, with registrations being more of a time-consuming task for the staff (16).

One feature of the innovation that many key informants appreciated was the highly effective helpdesk. This feature provided the participants with direct and immediate feedback from the physicians or nurses. Studies have noted that with the complaints on the helpdesk have helped identify when systemic improvements within the drug system should be made (22). Likewise another mhealth project, WelTel, a texting intervention in Kenya adopted this feature and expressed how the patients felt someone cared and provided direct care (23). WelTel allows individuals to have an integrative experience with medical professionals virtually through the two-way texting platform, which greatly increased treatment adherence and was cost-effective (24). Overall, this improved the culture of care between the patients and medical staff as it became easier to access care.

Innovation costs and funding

Many key informants expressed that the high costs of data for the intervention was a limitation in scaling the program. South Africa has one of the highest rates of data. Although the costs of data were covered for the participants, the rates were still very expensive although it was supplemented by telecoms companies. The cost of USSD was discussed in another study to be covered completely and this meant there was no cost to the end-user, which encouraged women to register because it was free of charge (19). Similarly, mHealth programs are attributed to be successful due to their relatively cost-efficient use of technology. A study highlighted that the low- and middle-income countries including South Africa

achieved high mobile penetration levels of 60%, thus this allowed mhealth programs to utilize existing technologies to save on costs (25). However, many mHealth innovations conclude that the financial sustainability of the mHealth interventions to scale and mobilize funders could be further strengthened with concrete evidence. Funding for large-scaled project implementation with the government needs to be realistic because ICT projects cost more than what is initially planned (26). Achieving the 'Goldilocks zone' is ideal, providing the technology requirements, scope for future scaling and its affordability, while also matching with the project's requirements for implementation (26). The Mobile for Reproductive Health (m4RH) project was an SMS based health information services. It was noted that the SMS data collection method utilized in the project was fast and cost-effective to learn more about the users and functionality of the platform (27). This greatly supported future scaling of the innovation and securing future funding (28).

Operationalization of the innovation

One major strength in the implementation of MomConnect program was the adaptations made with respect to the South African context, as this truly increased the accessibility of the program to the respective participants. One of the early-on decisions made when implementing MomConnect was to utilize a lot of existing technology to better scale and implement MomConnect. Another study similarly established that MomConnect made the early decision for universal coverage by designing the program to utilize basic technology that was easily accessible, such decisions strengthened MomConnect's ability to scale and implement (19). MomConnect utilized these pre-existing technologies and effectively adapted the MAMA project to allow for an easier implementation in the South African context. The users were able to adapt and accept the technology used because it was known, Brinkel and others noted in their study user motivation and technology acceptance were highly important and a basic requirement to implement a program effectively (29). As user attitude, acceptance and comprehensibility of mobile health in healthcare is important and sensitive (29). A study on the effectiveness of mHealth in medication adherence solutions showcased that about 40% of patients who were enrolled in sub-Saharan African antiretroviral therapy programs discontinued their program within 2 years (30). Patients in sub-Saharan Africa had limiting conditions that led to their poor drug adherence, this included bad weather, transportation, health conditions preventing them from leaving home, language barriers, etc. However, with the mobile technology SIMpill, patients receive alerts when they have forgotten to take their medication as prescribed and further alerts family members or friends if patients continue to neglect mediations (30). This mHealth program showed a significant success rate in treatment of 94% from participating in the system (31). Thus mHealth can provide services that can effectively adapt to the needs of the local community or population which increases the services sustainability and ability to scale. This study's results demonstrated how the positive feedback provided by the mothers was a large benefit in facilitating interest and scaling the program in South Africa. The women acknowledged that the messages were appropriate and felt personalized which made it feel like the physicians truly cared, this encouraged further scaling and implementation. Additionally, an evaluation study highlighted South

Africa had high literacy rates among adults this made texting a common activity on mobile phones and was appropriate way for the mHealth program to be scaled (11).

Policy & legislation

Lastly, identifying the political policies and legislations upheld by MomConnect demonstrated how the project was effectively scaled and implemented among all these regions in South Africa. The project put the South African Health Normative Standards Framework (SAHNSF) into practice which provided a structure on how the project should be managed and scaled in South Africa. This made it easier to surpass any technical hurdles that could have come up if the framework were not utilized from the beginning of the project. In a study conducted on optimising health information systems in South Africa, SAHNSF was emphasized to be imperative in following standards and keeping interoperability among the different national health information systems (17). One study depicts the importance of defining standards and protocols, having a framework allows the program to be implemented in a swift operational manner (32). In addition, with the application of mHealth projects that need to be implemented on large and national scales, it is important that national e-health strategies and frameworks are in place that can create the enabling environment for the implementation and scale of such projects as was the case for South Africa vis a viz the e health strategy and the National Health Normative Standards Framework for Inter-operability in eHealth (33).

Scaling mHealth programs

The use of policies or legislations to implement mHealth innovations are important to ensure it is swift and easy from the beginning of implementation as it provides a better understanding of any of the implementation hurdles that may come up. In the case of MomConnect the South African Health Normative Standards Framework (SAHNSF) was utilized. This framework proved to be effective as it helped prevent any technical hurdles, thus maintaining the use of this framework will be beneficial for the program overall to maintain the ability to effectively scale and implement the program further.

One critical factor in MomConnect that was revealed from this study is the role of champions in the program as these partnerships impacted the implementation and scaling of MomConnect. Having a strong top-down leadership was greatly important to help the program successfully scale in a timely manner. Many studies determined how impactful a government commitment from the beginning of a program can help scale the program nationally (34). MomConnect was one of the very few programs that was donor-funded program and adopted by the government (34). Stakeholders noted that MomConnect was unique in respects to the persistent political push from the government, which helped the program scale effectively. Though the top-down leadership helped scale the innovation quickly it also limited the amount of time available to establish bottom-up support for the program. As such ground-level workers such as nurses had criticisms about the facilities and how they were being conducted given the lack of support and resources they were given to run the program. In addition, the rapid scaling helped the

program gain attention, but it limited the amount of time available to conduct a pilot or baseline study. Stakeholders note that the program was under pressure due to timeline restrictions by NDOH stakeholders. The baseline study is important in evaluating MomConnect's implementation and scaling opportunities. It determines whether the program can sustain funding and provide proof of return for the program's government stakeholders. One study, expressed their evaluation of the MomConnect program was limited due to the rapid nationwide scaling efforts, an adequate baseline data was not collected, this made it more difficult to showcase the benefits of the program in comparison to other health interventions (10).

There have been calls for more evidence on the impact of mHealth interventions on health outcomes (6). MomConnect was able to subside a lot of the traditional research steps because they had the attention of the national government. However, stakeholders have mentioned that impact evaluations (RCTs) on MomConnect are about to kick off, which will support the evidence base data on the program's impact. It is important for health programs to envision a bottom-up approach, targeting local needs and creating a more sustainable program with the knowledge and evidence. Conducting evaluation studies or pilots, collecting evidence and support from project stakeholders and local organizations can help a project scale more effectively and attract adequate funds from diverse donors. As indicated in another review, there is generally a paucity of data on the impact of mhealth on patient outcomes in LMICs (35).

Language translation was a key factor in the MomConnect program. Although the program was able to translate the content into the 11 official languages of South Africa, there were issues with the quality of the translation. Similarly, another study that assessed the experiences of users' from different language and cultural groups, found out the quality of the translation in the Xhosa language was difficult to understand and not all languages were available in every community (36). Because the women were unable to understand the translations offered in Xhosa they were forced to request the service in English which was not as convenient to understand, limiting engagement (36). mHealth projects have been proven to be successful when they are adapted to the local context and language, thus this is an important component of mHealth project implementation (37).

Another compelling theme based on this study was the high cost of data and the reliance on donors for appropriate funding. The high cost of data is an issue that has persisted among South Africa due to the monopoly telecommunication companies hold on market prices for data (38). One study reveals in South Africa's past efforts to revamp the telecommunications sector, they sold their stakes in state-owned networks to companies such as Telkom, who exercised their monopoly power by raising prices and ultimately betrayed the government (39). Although there was a significant adoption of the program it was not successfully implemented in all regions of South Africa, as one study states about 10% of the population had no access to cellphones (40). In a recent systematic review, high cell phone rates were highlighted as one of the impediments to transitioning to scale of mhealth projects in Africa (41). Thus, one recommendation to help reduce the dependence on telecom companies and donors to provide support and funding assistance, is utilizing mobile applications such as WhatsApp where there are no costs for SMS and is more consistent. This could help with scaling the project to other regions and

registering more participants. Additionally, with the significant adoption rates of mobile phones with smartphone application use there is a higher chance of participants registering and keeping up with the program.

Strengths & Limitations

Our study showcases the viability of using the CFIR framework to identify common barriers and facilitators in the implementation of mHealth innovations. Its ability to utilize a standardized language to analyze the various barriers and facilitators mentioned by key informants. This framework was used as a part of the data analysis tools [see Additional File 2 Qualitative Study Checklist]. A potential limitation was our selection of a determinate framework (CFIR) as they have been criticized for their inadequacy in addressing causal mechanisms or how change takes place (42). However, the use of the CFIR allowed the findings to be placed in the context of the wider implementation research literature (43,44).

We also acknowledge that our stakeholder sample only involved stakeholders who were partners and implementers of the MomConnect program and not users of the innovation. However, we would like to recognize that there are existing studies that have examined the user perspectives and ability to use the program (35,45). One study noted that the users in MomConnect were consistently positive about the impact of the messages and their online access.

Conclusion

This qualitative study demonstrates that CFIR is a useful tool that can be used to guide the formative evaluation processes of mhealth programs. The barriers and facilitators identified under the CFIR domains can be used to build knowledge on how to adapt mhealth programs to national and local settings. Key areas of importance for mhealth programs as revealed by this study include (1) strategic partnership and coordination across multiple sectors, (2) resource mobilization costs and funding; (3) operationalization of the innovation to local and national setting and (4) mhealth policy and legislation frameworks. The results of this study can inform the planning and design of new and ongoing evaluations and can serve as a foundation for the effective design and scale of mhealth interventions.

Abbreviations

CFIR: Consolidated Framework for Implementation Research

LMIC: Low- and Middle-Income Countries

PDA: Personal Digital Assistants

USSD: Unstructured Supplementary Service Data

SMS: Short Messaging Service

MAMA: Mobile Alliance Maternal Action

NDOH: National Department of Health

SAHNSF: South African Health Normative Standards Framework

Declarations

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Availability of data and materials

Not applicable

Competing interests

The authors declare that they have no competing interests

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Authors' contributions

Study conception and design: OE. Analysis and interpretation of data: CV, SR and OE. Draft of the manuscript: CV and OE. Critical revision of the manuscript for important intellectual content: CV and OE. All authors read and approved the final manuscript.

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Tables

Table 1: Key informant-identified barriers and facilitators to the implementation and adoption of MomConnect domain and construct (n = 15)

CFIR domains (n = 5) and constructs (n = 39)	Barrier n (%) of interviews	Facilitator n (%) of interviews
I. Intervention characteristics		
A. Intervention Source	N/A	N/A
B. Evidence Strength and Quality	8 (53.3%)	N/A
C. Relative Advantage	N/A	N/A
D. Adaptability	4 (26.7%)	7 (46.7%)
E. Trialability	N/A	N/A
F. Complexity	N/A	N/A
G. Design Quality and Packaging	7 (46.7%)	14 (93.3%)
H. Cost	9 (60%)	7 (46.7%)
II. Outer Setting		
A. Patient Needs and Resources	N/A	N/A
B. Cosmopolitanism	5 (33.3%)	N/A
C. Peer Pressure	N/A	N/A
D. External Policy and Incentives	N/A	1 (6.7%)
III. Inner Setting		
A. Structural Characteristics	N/A	N/A
B. Network and Communications	N/A	N/A
C. Culture	N/A	N/A
D. Implementation Climate	2 (13.3%)	2 (13.3%)
1. Tension for Change	N/A	N/A
2. Compatibility	4 (26.7%)	6 (40%)
3. Relative Priority	N/A	N/A
4. Organizational Incentives and Rewards	N/A	N/A
5. Goals and Feedback	N/A	N/A
6. Learning Climate	N/A	N/A
E. Readiness for Implementation	N/A	N/A
1. Leadership Engagement	N/A	N/A
2. Available Resources	9 (60%)	2 (13.3%)

3. Access to Knowledge and Information	4 (26.7%)	N/A
IV. Characteristics of Individuals		
A. Knowledge and Beliefs about the Intervention	N/A	N/A
B. Self-Efficacy	N/A	N/A
C. Individual Stage of Change	N/A	N/A
D. Individual Identification with Organization	N/A	N/A
E. Other Personal Attributes	N/A	N/A
V. Process		
A. Planning	N/A	N/A
B. Engaging	N/A	3 (20%)
1. Opinion Leaders	N/A	N/A
2. Formally Appointed Internal Implementation Leaders	1 (6.7%)	N/A
3. Champions	4 (26.7%)	14 (93.3%)
4. External Change Agents	N/A	4 (26.7%)
C. Executing	N/A	N/A
D. Reflecting and Evaluating	N/A	N/A

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Table 2: Barriers, facilitators and their respective CFIR constructs

Barriers	CFIR Domain (Construct)	Facilitators	CFIR Domain (Construct)
<p>High cost of data</p> <p>“So one of the problems we have in South Africa is the cost of our data is so high, we have some of the highest cost data in the world...” (Int.11)</p>	Intervention Characteristics (Cost)	<p>Easy and accessible technology</p> <p>“...it is a technology that is accessible to all and that makes a huge difference.” (Int.11)</p>	Intervention Characteristics (Design Quality & Packaging)
<p>Uncontrollable market fluctuations</p> <p>“... I think you can do so much for the technology, but the barriers to the use of technology are often about the market and that’s something that the department of health always will struggle to affect.” (Int.11)</p>	Intervention Characteristics (Cost)	<p>Positive user feedback</p> <p>“There was very good response from users, moms love it. Testing with mothers provided very positive feedback, being human centered in design here was a good response. Which helps for scale because mothers encourage other mothers and urge them to ask for this.” (Int.2)</p>	Intervention Characteristics (Adaptability)
<p>Inadequate internet connectivity</p> <p>“We actually had quite a few of those barriers, just to highlight some – one was the issue of internet connectivity, SA is having an issue of connectivity. There needed to be internet connection to register pregnant women, this contributed to low registration.” (Int.1)</p>	Intervention Characteristics (Design Quality & Packaging)	<p>Effective two-way communication</p> <p>“Two-way messaging is much more powerful than one way; required establishment of help-desk and staffing and FAQ’s and process of logging in those complaints and escalating complaints appropriately in department of health.” (Int. 2)</p>	Intervention Characteristics (Design Quality & Packaging)
<p>Unreliability of USSD</p> <p>“...there’s quite a number of registration fields that need to be completed, and to do all of that over USSD is quite tricky...I’m not sure if</p>	Intervention Characteristics (Design Quality & Packaging)	<p>Effective content adaptation</p> <p>“And obviously these are all the adaptations they made along the way and also in terms of you know your age groups. So somebody who’s a</p>	Intervention Characteristics (Design Quality & Packaging)

<p>you're familiar with USSD, you have a session and in the session if it times out or if the connection is broken or minimal you have to dial it up again and get that connection..." (Int. 13)</p>		<p>teen mom is not very excited about SMS whereas somebody who is much older maybe easier to work with in SMS as opposed to working in an app. So the content started evolving overtime so that there were different things to bring people again and gain interest." (Int.10)</p>	
<p>Inadequate training</p> <p>"The training from what I could tell was not done. I think there was a standard way to that was intended for the training, but it didn't turn out that way. Everybody got a little bit different level of training, little bit different kind of training." (Int.6)</p>	<p>Inner Setting (Available Resources)</p>	<p>Effective guidelines from MAMA</p> <p>"I think that it took a lot of the model from MAMA and the content and then it completely reworked it to the South-African context. I think that, that it made it easier." (Int. 6)</p>	<p>Intervention Characteristics (Design Quality & Packaging)</p>
<p>Gaps in funding</p> <p>"I do know that there was not any government or very limited if there is any government funding going to the Mom Connect project and it was mostly donor funded." (Int.12)</p>	<p>Inner Setting (Available Resources)</p>	<p>Strong political will</p> <p>"There was very strong and very senior level government buy in for the Mom Connect project, as it was being implemented in a way that I've never seen. I have never seen with any health project before that such a senior level individual in the Department of Health would be so interested in getting mHealth project implemented at as large of a scale as possible, as quickly as possible, so that was a significant benefit that I haven't seen before." (Int. 12)</p>	<p>Process (Champions)</p>
<p>Insufficient publicity</p> <p>"I don't know if there is enough signage in these facilities around this. I haven't seen any radio adverts or TV adverts about it." (Int. 10)</p>	<p>Inner Setting (Available Resources)</p>	<p>Strong stakeholder champions</p> <p>"...what made the project so successful was also the collaboration – and was the partners that really did come together, and each had a really unique perspective, and</p>	<p>Process (Champions)</p>

		a really focused area of work within the project.” (Int. 4)	
Inadequate language translation	Intervention Characteristics (Adaptability)	Cost-efficient technology	Intervention Characteristics (Cost)
“...some instances, there were a few issues with the translation of the Xhosa the dialect which was because of the difference between the dialects spoken in Eastern Cape and the used in the translation of any of the guides...” (Int. 7)		“A combination of SMS, WhatsApp and USSD, or relatively inexpensive technologies...” (Int.13)	
Unequal mobile access	Intervention Characteristics (Adaptability)	Cost-effective messaging system	Intervention Characteristics (Cost)
“...the moment you move to an application it becomes slightly harder because then you need compatibility with the phone.” (Int. 10)		“So Vodacom was the service provider that we worked with. And when we worked with them, they subsidized the costs of the SMS’s... we found it easier for us to reach more people because the costs were subsidized.” (Int. 10)	
Insufficient baseline	Intervention Characteristics (Complexity)	Smooth integration process	Inner Setting (Compatibility)
“Because we just did it so fast, we didn’t really do a proper baseline and very quickly there was nothing we could really compare it to. And I’d say that was the single biggest problem. Because that meant we couldn’t actually come up with anything that was convincing to show the impact of it...”(Int.5)	Process (Planning)	“We can go back and look at actual facts, it was working in over 90% of health facilities in South Africa. That is amazing. You don’t get aspirin in 90% of the health facilities in South Africa”(Int. 5)	
Inability to test intervention	Intervention Characteristics (Trialability)	Effective project promotion	Process (Engaging)
“...we went national almost immediately and we didn’t have a clear RCT that we ran or even a staple model to build up the evidence in a very robust way that this		“...things like marketing materials, having ministers talk about these things in public forums and newspapers and things like that has kind of shown it to	

<p>was worthwhile from an impact perspective, which really has delayed our ability to be able to put a clear return on investment case for it.” (Int. 3)</p>		<p>be a flagship program of the NDoH.” (Int.4)</p>	
<p>Timeline pressure from stakeholders</p> <p>“The department, they wanted to implement and scale very fast, and so it was a massive, radical experience and we didn’t have the time to set up a really nice study ahead of time...” (Int 13)</p>	<p>Process (External Change Agents)</p>	<p>Appropriate content translations</p> <p>“There are nine official languages in South Africa and the minister said yes it had to be in every one. We did proper translations. If you know the term back translation, so there were some verification of it.” (Int.5)</p>	<p>Intervention Characteristics (Adaptability)</p>
<p>Incompatibility with health system</p> <p>“...there was a number of facilities throughout South Africa that just refused to do this work that felt was imposed on them when they were already stretched for resources, for time, for staff they felt they just did not have that—the ability to add one more thing to their list of things to do...” (Int.12)</p>	<p>Inner Setting (Compatibility)</p>	<p>Sufficient donor funding</p> <p>“And of course, having funders who could commit, say to 3 years of funding. Initially there was a lot of funding which was made available for the initial pull, a lot.” (Int.13)</p>	<p>Inner Setting (Available Resources)</p>
<p>Insufficient government buy-in</p> <p>“Another barrier was lack of support from premier principals. People who were involved in launching MomConnect – we needed operational managers and we find that the CEOs and the others were not involved... There was disconnection between what they were doing and probably the vision of the principals.” (Int.1)</p>	<p>Process (Champions)</p>	<p>Comprehension of user needs</p> <p>“...the content that was created was really great and it’s obviously a time of the person’s life – the woman’s life where they’re extremely engaged and really, really hungry for knowledge. So I think the content was extremely important and also making a mom feel like she’s not alone and there’s someone providing her with just some messages to reassure her and support her and understand where she is.” (Int.13)</p>	<p>Inner Setting (Compatibility)</p>

Gap in technical leadership “...an NDoH technical lead who understood the technology stacks. You know that kind of person is hard to find and generally is quite an expensive resource which the national department of health didn’t have.” (Int.14)	Process (Formally Appointed Internal Implementation Leaders)	Effective immediate scaling design “...the system architecture that was developed from the start was built to scale... It wasn’t built to be a pilot I think is one of the things that’s enabled it to be successful there was this vision of scale from the start and it was built accordingly.” (Int. 4)	Intervention Characteristics (Trialability)
Stakeholder mismanagement “The hardest part of all was trying to get everybody linked up and to get adequate political pressure in enough places.” (Int.9)	Outer Setting (Cosmopolitanism)	Strong partner relations “MomConnect had a strong relationship with HIPPA and the NDoH, etc. so the combo of strong top-down directive created a strong relationship between the health system. Also a very strong leadership particularly in the minister; strong top-down director coupled with simple tech, and relationship amongst the funders, and with HIPPA and NDoH made the project scale quickly.” (Int. 2)	Process (External Change Agents)
Insufficient evidence to scale “They didn’t pilot the MomConnect platform so there was no proof that it could work.” (Int.1)	Intervention Characteristics (Evidence Strength & Quality)	High literacy rates “Additionally and this relates back to the lessons learned in the MAMA project not every medium resource country, and especially not every low-resource country has high literacy but South Africa does have very high literacy.” (Int. 12)	Inner Setting (Implementation Climate)
Pushback from focal people “Some workers felt like it was an added burden and felt like it was an additional	Inner Setting (Implementation Climate)	Cleaner registration system “...they insisted women should only be registered if there was confirmed pregnancies and it had to be	Intervention Characteristics (Design Quality & Packaging)

task in need of fulfilling..." (Int. 2)		at a healthcare facility by a healthcare worker, there was much cleaner database because of this..." (Int.2)	
Unequal access to information "the nurses were saying these women are getting information we don't know what it is, sometime this information we don't know ourselves, we want to know what we are giving them" (Int. 11)	Inner Setting (Access to Knowledge & Information)	Addition of Whatsapp "Because when most people receive an SMS, that's it, they read it and that's it. But if you receive a text on WhatsApp, the mental association is you are more likely to respond to it. Because WhatsApp is more conversational communication, while SMS is one push boom, it's not a conversation it's just one bit of information spat out at you." (Int.5)	Intervention Characteristics (Design Quality & Packaging)
Inadequate privacy features "...you have to be very careful about was the fact that it's a SMS there is no form of privacy around it. So anybody could pick it up and read it..." (Int. 10)	Intervention Characteristics (Design Quality & Packaging)	Efficient coding system "Each facility then was assigned a 6 digit code which through a kind of standardized approach that we recommended and that was then implemented into the whole structure. Without that coding system we wouldn't have been able to realistically get the flows into making it simple to identify where the data was coming from... helped design up the reports which would give the maximum information back to the government to then help put on the further implementation." (Int.9)	Intervention Characteristics (Design Quality & Packaging)
Insufficient support for individuals with HIV "We had—one of the things that MAMA had that MomConnect did not have	Intervention Characteristics (Adaptability)	Effective automation system "So with an automated system it decreases the human error but it also increases the feasibility of	Intervention Characteristics (Design Quality & Packaging)

<p>was a large focus in a separate stream of messages for HIV positive women and because the population we were working with in the inner-city Johannesburg the HIV positivity rate was around 30%.” (Int. 12)</p>		<p>reaching more people” (Int. 10)</p>	
<p>Inability to register privately or postnatally</p> <p>“Some women receive ANC in the private sectors because they prefer evading wait times, but will transfer to public sector for delivery because they can’t afford the delivery part of care. So they may not be registered to MomConnect because you can’t register privately or postnatally either. So she’ll miss out on the information provided by MomConnect.” (Int. 2)</p>	<p>Inner Setting (Compatibility)</p>	<p>Effective group registration system</p> <p>“We introduced group registration; take details of clients...they would register them before they go home or early in the morning before they start, this decongests the system and can reduce the load of registration.” (Int.1)</p>	<p>Intervention Characteristics (Design Quality & Packaging)</p>
		<p>Adaptation of legislation</p> <p>“MomConnect set out to put into practice, the South African Normative Standards Framework...having those principles and standards and legislations in place already, it made it easier to get passed some of the technical hurdles that might be hurdles in other places where there isn’t that standard framework to start with.” (Int.4)</p>	<p>Outer Setting (External Policy & Incentives)</p>

Table 3: Overarching thematic areas identified from included studies across commonly reported Consolidated Framework for Implementation Research (CFIR) constructs

Thematic Areas	Description	CFIR Construct (CFIR Domain)
Partnership relations	Support of the innovation by a diverse group of partners both external and internal with their unique expertise, mutually reinforcing the implementation process.	Champions (Process) Cosmopolitanism (Outer Setting) Formally Appointed Internal Implementation Leaders (Process) External Change Agents (Process) Access to Knowledge and Information (Inner Setting)
Innovation costs and funding	The cost of the innovation and the impact of the funding stream on the execution of the innovation.	Cost (Intervention Characteristics) Available Resources (Inner Setting)
Operationalization of the innovation	The ability for the innovation to adapt appropriately to meet local needs and South African context while also creating sustainable measures of scaling.	Design Quality & Packaging (Intervention Characteristics) Adaptability (Intervention Characteristics) Evidence Strength & Quality (Intervention Characteristics) Compatibility (Inner Setting) Engaging (Process) Implementation Climate (Inner Setting)
Policy & legislation	Support of the innovation by policies and legislations that helped set principles and standards to surpass any hurdles in implementation.	External Policy & Incentives (Outer Setting)0

Figures

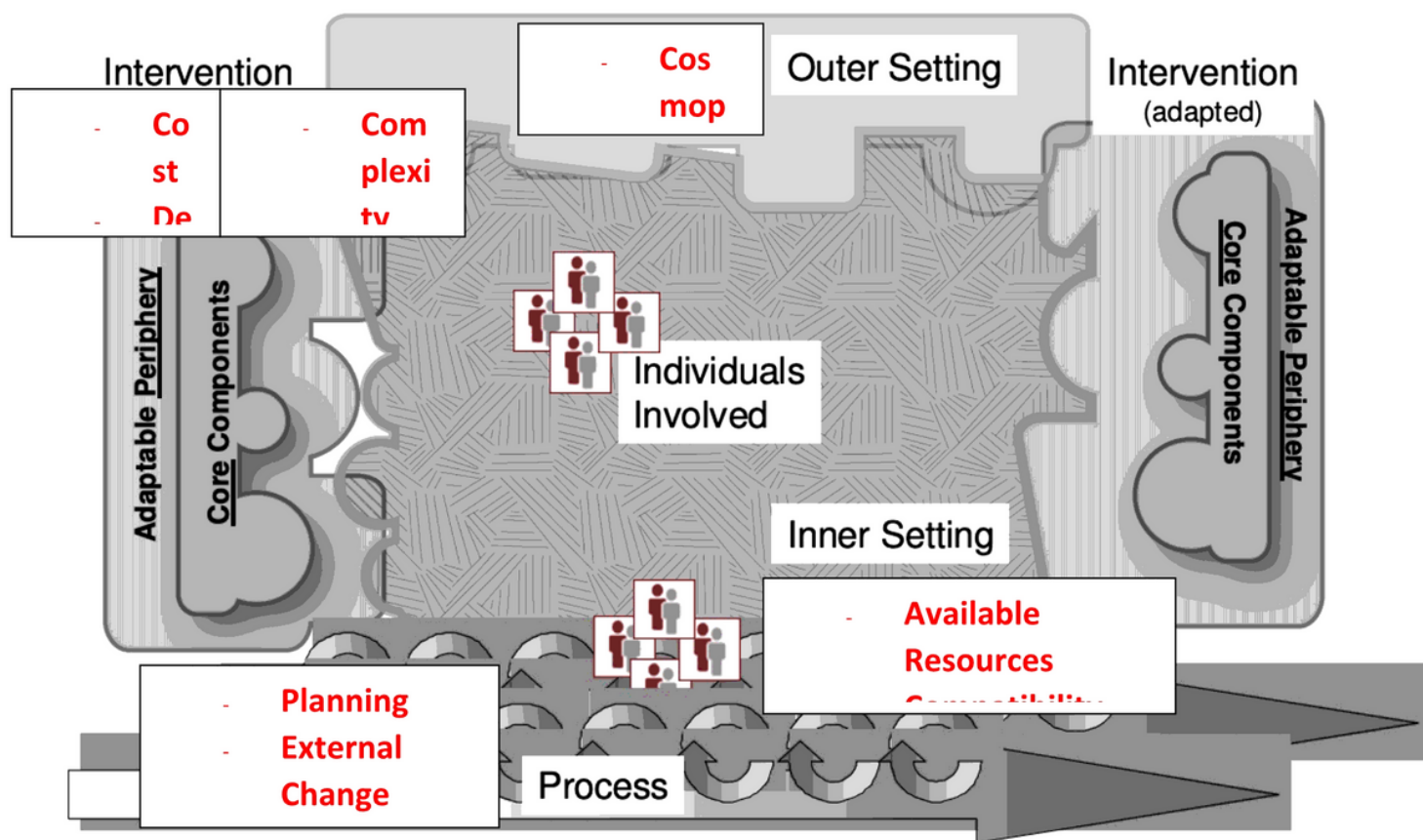


Figure 1

CFIR domains and constructs which emerged in the study (20)

Supplementary Files

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