Extension of MoTeCH for Postpartum Care in Ghana

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1   Introduction

While improving child and maternal mortality are the fourth and fifth of the Millennium Development Goals (MDGs), at the current level of progress, most Sub-Saharan African countries will not achieve these goals by the 2015 deadline [19]. Ghana falls in the category of countries that will likely achieve MDG 4 by 2025 and MDG 5 by 2040, with a current infant mortality rate of 49 in every 1,000 live births and maternal mortality rate of 350 maternal deaths in every 100,000 live births [30].

An interesting and parallel trend in Ghana is the increase of technological use. The estimated mobile penetration rate in Ghana is 113.37% and the mobile broadband penetration is 33.3%, putting Ghana as Africa's top mobile broadband performer [31, 9, 4]. While the number of mobile subscriptions is inflated by the multiple-subscription of SIM cards and it also does not reflect the disparity in coverage of mobile devices, it is still indicative of the growing prevalence of mobile phone usage across the country [11].

The Ghana Health Service has launched the Mobile Technology for Community Health (MoTeCH) initiative, which utilizes this growing trend of cell phone usage to reduce maternal and child mortality [20]. The project includes components for data collection nurses, mobile midwife for expecting parents, and appointment and vaccination reminders for mothers [16]. It is currently being deployed in subdistricts in the Upper East region of Ghana and baseline evaluations in collaboration with the Navrongo Health Research Center has evaluated efficiency of health workers as well as health seeking behavior [28]. However, this project also faces limitations in its restriction of scope to addressing mainly antenatal concerns.

This project proposes to spend $1 million on an extension of the MoTeCH platform to include interventions that focus on postpartum care, specifically on the outcomes of increased breastfeeding, adherence to postnatal supplements, and early care seeking for neonatal infections and the strengthening of the community infrastructure that would aid in the supplementation of this program.

2 Country background

2.1 Economic background

Ghana is a small lower middle-income located in West Africa with a GDP per capita of $1,645.52 and a population of approximately 25 million people. However, 28.5% of the population live below the poverty line [8].

2.2 Health background

The health coverage is fairly poor, with 0.1 physicians for every 1,000 patients [8]. The Ghanaian health system is organized around districts and subdistricts, with community-based planning and services (CHPS) initiatives, meaning the level of care varies across different districts [27]. This calls for the need for some means of bridging the gap for health distribution, whether it is more trained personnel or an intermediate solution that uses technolgoy to provide information and communication between the patients and their healthcare providers [13].

Accelerated socioeconomic and demographic changes of the epidemiological transition and burden of chronic disease creates a protracted double burden of infectious and chronic disease, polarized across social class [1]. This has increased attention towards noncommunicable diseases and plans for prevention to reduce Ghana's dual disease burden [24].

However, ultimately, most of the mortality in Ghana can be traced back to communicable diseases, accounting for 53% of deaths [24]. The top five causes for death with regards to years of life lost (YLL) include malaria (16.2%), HIV/AIDS (9.8%), lower respiratory infections (8.1%), neonatal sepsis (7.2%), and preterm birth complications (4.5%) [14]. However, with age-standardized rates of disability-adjusted life years (DALYs), the diseases with the greatest burdens with regards to the absolute number of DALYs are malaria, lower respiratory infections, diarrheal diseases, measles, and neonatal sepsis [14]. Moreover, neonatal sepsis in Ghana is ranked as the worst performance across comparator countries in terms of age-standardized DALY rates [14].

2.3 Neonatal and maternal health

These statistics point to the postnatal period as a key insight into reducing DALYs burdens, specifically with regards to diarrheal diseases and neonatal sepsis. Every year, there are on average 776,000 births and a total population of 3,592,000 of under five individuals [8]. However, out of those, there are 60,000 under five deaths, 38% of which are neonatal deaths [26].

Currently, the approach for maternal and child care is focused on antenatal care. Once a woman is identified to be pregnant, she is asked to attend the requisite 4 antenatal care visits in the clinic [18]. At these visits her information is kept in a large register among other pregnant women and she is given two paper booklets to maintain before, during, and after her pregnancy including a schedule of upcoming care. One booklet was used to track the health of the mother, and the other, of the child. While these books do include pictures and some descriptions of best practices for antenatal care, the book is designed mainly for the use of nurses for data collection and is not very useful for the women [24]. This is compounded by the fact that while the literacy rate in Ghana is 71%, females are 83% of males in adult literacy rates [30].

Even though the WHO's definition of maternal mortality extends 42 days past the termination of pregnancy, postpartum care is less discussed than antenatal care [23]. Postpartum care has the potential to have more impact because it does not rely on extreme predictions, rather, can affect those who are in immediate danger. Having follow up visits could improve maternal and infant health as women who birthed in the public sector appeared more satisfied because they had higher odds of receiving contact from a health professional within 10 days post-discharge [5]. Furthermore, postpartum care is intertwined with neonatal care which means it could impact both maternal and neonatal mortality as well as be more effective in targeting diseases such as neonatal sepsis and diarrhea that have DALY burden.

2.4   Resource allocation

Overall, Ghana has improved its health outcomes, and yet, on average, has not achieved the health outcomes found in other lower-middle-income countries on a global level that are comparable to Ghana's income and spending for health [24]. Ghana spends approximately $27 per person for publicly funded health care resulting in health spending taking up approximately 14.6% on total government spending and about 5.2% of the GDP [6, 24]. Financing for health costs stems mainly from the National Health Insurance Scheme (NHIS), which covers about 80% of the population, and the National Health Levy (NHL) of 2.5% VAT-like tax on certain goods and services along with other taxation covers about 50% of health financing [2].

However, coverage with the NHIS is less than spectacular. Less than one-half of the population has insurance and are expected to pay for their healthcare out-of-pocket at or above market prices, driving out-of-pocket payments to account for 45% of of funding [2, 24]. Figure 1 shows a simplified diagram how the funding moves in public sector healthcare.

Donor spending averages to about $6.60 per capita with 44% of it given to the public sector [24]. HIV is the main marked donor funding cause, with the majority of the remaining
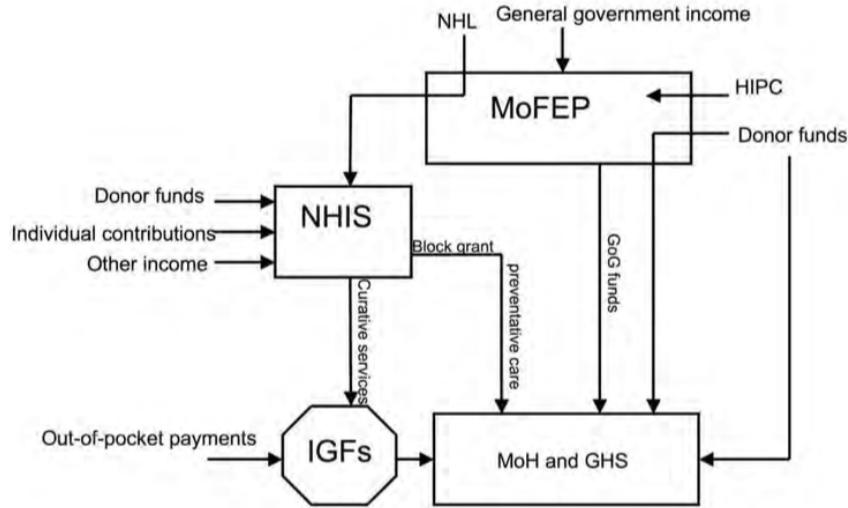
Figure 1: Diagram of Ghana public sector healthcare financing [24].

amounts budgeted for general funds and some left for earmarked funds and equipment and buildings [24]. However, as seen in Figure 2, donor funding is unpredictable in terms of the quantity that is received and how it is split. Within the Medium Term Economic Framework designed for budgeting, $2 million dollars was promised for HIV but only $300,000 was received [22].

	Ghana cedis (x10^6)		US dollars (x10^6)	
	Planned in Medium Term Economic Framework.	Received in first three quarters of year (Jan – Sept)	Planned in Medium Term Economic Framework.	Received in first three quarters of year (Jan – Sept)
HIV	3.10	0.44	2.20	0.31
Earmarked funds	5.62	0.96	4.00	0.68
General funds	50.5	90.0	35.8	63.8
Equipment/buildings	2.65	12.8	1.88	9.04
	61.9	**104.2**	**43.9**	**73.8**

Figure 2: Breakdown of donor spending for health in Ghana, 2009 [22].

3 Health intervention: MoTeCH for postpartum care

3.1 Main implementation points

The current implementation of the mobile technology for community health (MoTeCH) project has shown strength in leveraging the existing technology trends to address a pressing problem in Ghana. This builds upon previous work about the use of mobile phones in the

country, including the idea that mobile phones have been well integrated into the lifestyle to the point that while they are not an overt means of poverty reduction for respondents, their integral position can be leveraged for more change [29]. Examinations of the use of information and communication technologies (ICTs) in poverty reduction programs have recorded a range of benefits including income generation, savings in money and travel time, access to market information, government services, healthcare, and political empowerment [7, 25].

The current MoTeCH deployment includes the following three:

- A **digital register** allows nurses to track and report information regarding maternal and child health for each of their patients in a reliable and consolidated manner.

- New and expecting mothers can use the **mobile midwife** to receive tips and ask questions about the antenatal process through text messages or the interactive voice response (IVR) system.

- **Reminders and alerts** allow nurses to send text messages to encourage their patients to come back to the clinic for scheduled appointments and vaccinations.

The proposed project will build upon the existing foundation of MoTeCH and extend the existing MoTeCH intervention in the following manners:

- **Postnatal supplement reminders** sent through the reminder system can help increase adherence to these prescribed dietary supplements: iron and folic acid.

- **Breastfeeding encouragement** will both give information about the benefits of breastfeeding as well as reminders to do so.

- Information about recognizing the symptoms of neonatal afflictions such as jaundice or neonatal sepsis can help increase **neonatal care seeking** on part of the mothers.

The MoTeCH project has done a stellar job in establishing the groundwork for a framework for deploying a comprehensive mobile health intervention for maternal health. The project has carefully completed an assessment of the technological accessibility and capabilities in the deployment sites, gathering nurse and client consent, testing the use of incentives for the nurse data collection, creating content, marketing the product, building the call center, developing the software, and thinking about evaluation and sustainability [16].

Each of the extensions presented will build upon the existing structure of MoTeCH. This will be able build upon the technological infrastructure, using the existing SMS and IVR abilities to send informational and reminder texts and calls like in the mobile midwife and

reminder modules of MoTeCH. In addition to reducing software development costs, this project will decrease many of the fixed costs and start-up efforts associated with the deployment, including mobile phone availability, marketing, and more. Therefore, this proposed implementation would be able to focus on the evaluation and the improvement of select health outcomes.

3.2 Target population

This project hopes to impact the new mothers and neonates. MoTeCH is currently deployed in the Upper East Region of Ghana, one of the 10 poorest regions in the country and the most rural, with a highly dispersed settlement pattern [20]. This region has a population of 1,026,458 individuals, 49.0% of which have no education, the second highest across the nation [26]. There are only 29 doctors in the region, meaning that there is 1 doctor for every 35,010 patients, not to mention the geographical boundaries that make health-seeking behavior even more difficult [26]. The statistics for maternal and child health are no less promising, with the institutional maternal mortality rate at 131 per 100,000 live births and infant mortality at 46 per 1,000 live births [26].

Since MoTeCH is currently launched in only a few of the districts of the Upper East Region, specifically the Kassena-Nankana and Kassena-Nankana West Districts, the goal of the extension is to reach out to the remaining districts and enlist those women in the process as well. The cost calculations are based on the population of the entire region and also take into account the need for system strengthening in the remaining parts of the region.

3.3 Plan of implementation

3.3.1 Content creation

The original deployers of MoTeCH aimed to create content that was "remarkably right", actionable, simple, localized, and medically sound through field inquiries (pregnancy question box, pregnancy diaries, and informal focus groups), base content created by major NGOs such as UNICEF, development with governmental health organizations, translation, localization and recording of messages, and finally field testing of these messages [16]. For the purposes of this project, a similar process will be followed, but making sure not to repeat completed efforts. For example, the content creation process would build upon existing understanding of the field inquiries and just start with the base content created by major NGOs and governmental entities and then translate these ideas before field testing. Due diligence will be given in order to ensure that there are not repeated messages or concepts in the messages sent to the new mothers.

	foods.
Week 13 primary message	Most Ghanaian women begin their pregnancy with low iron levels, so the midwife usually prescribes iron pills to correct that. You need iron because it keeps your blood doing its job of carrying food and oxygen around your body to keep it well. When you don't have enough iron you may feel tired and breathless too often. You could also get a condition called anemia, which can be dangerous for you and your baby. A baby who does not have enough iron is often born too small and so they face a lot of risks. To avoid this, it is important that you take the tablets given to you by your midwife. Iron is also found in many foods including liver, red meat, green leafy vegetables such as ayoyo, ademe, gboma, kontomire, spinach, bokoboko, bitter leaf, and eggs. Try to also take fruits such as orange, guava or baobab fruit these help the iron to enter your blood more easily. At this stage your baby is still small enough to fit into the palm of your hand. He or she is becoming more active – maybe even playing with the umbilical cord – grabbing it and letting it go. You might start feeling your baby move soon. This is called 'quickening'. At first, you might feel a slight movement low down in your belly. Some women feel their baby move later. If you haven't noticed anything yet, there is no need to worry but if you feel your baby moving, tell your midwife at your next appointment – share the good news!

Figure 3: A sample message from the current MoTeCH implementation.

The main concern for content creation is regarding the informational messages, which have content mainly centered around two main concerns: breastfeeding and neonatal care. This informational content can include reasons why breastfeeding is important, best practices for how to breastfeed, warning signs for jaundice or neonatal sepsis, and more. The other component of the intervention, or the reminders, will not need to undergo such a rigorous process of creation and adaptation, but rather, can build upon the existing reminders that have already been tested and deployed by MoTeCH. The informational topics will be conveyed through basic MoTeCH messages, an example of which is included in Figure 3. Additionally, these new messages will include culturally-appropriate encouragement, including using endorsement of well-meaning celebrities or adaptations of popular songs.

3.3.2 User solicitation

After the messages are created, the next step is collecting the user base. The extension will build upon the existing MoTeCH user base, specifically utilizing existing connections in the CHPS and local clinics to register new mothers who will be undergoing this new regimen of text messages in addition to the existing MoTeCH messages. When mothers first receive their antenatal care at their local clinics, they will be invited to participate in the program, which means that they would enroll via text message or call to receive their unique MoTeCH ID. The nurses would also give instructions on how MoTeCH works.

Previous studies in similar SMS-based approaches have found a user retention rate that is fairly low but still impactful. For example, in a study that looked at appointment attendance

with SMS reminders found the effect on appointment attendance using text message versus no reminder was increased, with a relative risk of 1.06 [17].

3.3.3 Schedule of messages

Month	Week	Breastfeeding	Neonatal care	Postanatal Supp	Appointment
1	1	Basics			
	2		Basics	Reminder	
	3	Reminder		Basics	
	4			Reminder	
2	5		Sepsis		
	6		Reminder		
	7	Reminder			
	8		Jaundice		Reminder
3	9				
	10			Reminder	
	11	Reminder	Dehydration		
	12				Reminder
4	13	Reminder			
	14				
	15	Reminder			
	16				
5	17	Reminder			
	18				
	19	Reminder			
	20				
6	21	Reminder			
	22				
	23				
	24	Congratulations!			

Table 1: Sample 6 month regimen of postnatal messages.

Each regimen of information will span approximately 6 months, which is the recommended amount of time for exclusive breastfeeding by mothers and is beyond 3 months, which is the critical period for postnatal supplements and neonatal sepsis. The number of relevant messages will naturally become less frequent as there are less pressing matters as time passes in gradual drop-off. As per the current MoTeCH implementation, each message will be accompanied with three attempts to reach to woman and ensure that she has received and understood the message. This is important because of the learning curve associated with the utilization of technology, the potential connectivity problems, or a generally busy or bad time.

An example of a potential schedule of messages loosely based on WHO guidelines for breastfeeding, neonatal care, and postnatal supplements is seen in Figure 1. In this example, the messages are staggered out across the different weeks in the 6 month postnatal period to vary the order of the types of and create and maintain interest. Some of the principles of the timing of the messages have to be adhered from previous studies [12]. It is also designed to effectively engage the women, increasing familiarity with MoTeCH and decreasing the barrier of communication with the call center to ask questions. At the same time, the proposed intervention will use only the number of messages necessary to convey important information and refrain from sending excess messages.

3.3.4 Physical check-ins

What is important to note is that this schedule is designed to intertwine both text and voice calls with the physical presence of a health worker. This will be in the form of appointment check-ins, where the new mothers and children will receive basic postnatal care and replenish any additional nutritional supplements. Additionally, there will be random check-ins by community health workers to see if the new mothers are understanding the messages that they are receiving. This will be mainly looking at whether the new mothers are breastfeeding their children with the proper technique, if they are able to identify basic warning signals, and if they are taking the proper postnatal supplements.

3.3.5 System strengthening

This proposed intervention will not only extend MoTeCH, but also strengthen the system surrounding it. Some of the money from the intervention will be used to strengthen the technological infrastructure, including purchasing mobile phones for new mothers who do not have phones and potentially purchasing a new server to handle more requests. These small improvements can help strengthen the technological basis for future mobile phone based interventions as well as provide a source of communication for the patients. There will also be substantial nontechnical system strengthening, including the availability of health workers to handle the higher volume of patients as well as maintaining the stocks of supplements.

3.4 Challenges

Some of the challenges that this project face include the following:

- As mentioned earlier, **literacy** is a major concern, specifically around women. The way this project and the MoTeCH project in general addresses this is through the

option for voice calls in addition to text messages as a means of information. However, the other type of literacy, or **digital literacy**, might prove to be a stronger roadblock in terms of uptake. For those who do not own phones or are just starting to use them, the interactions may be a little difficult. However, the user solicitation step includes training to the point that the women will be comfortable with the mobile phone and the small set of interactions necessary for MoTeCH. Furthermore, the current prevalence of mobile phones in conjunction with the women who have already used MoTeCH provide a strong population of people who can help with any efforts to learn the technology.

- One of the main problems to this type of mobile-based intervention is **adherence**, whether intentional or unintentional. There is the possibility that messages are missed. The possibility of missing messages is remedied in this solution and in the MoTeCH platform by maintaining persistence—having the three attempts to connect and then trying the day after to connect. Another possibility is that the messages are not understood or the more unfortunate situation where the messages are ignored. This is adjusted for with the check-ins, with the regular, scheduled visits as well as the random visits. Some attrition is expected, but putting in place some more measures of accountability can aim to slow its rate.

- With other mobile-based interventions, including the original MoTeCH intervention itself, one of the concerns is limited ability for **evaluation**. Since other mobile-based interventions seem to be more structural than specific to a given health outcome, it is hard to tell which component contributes to what aspect. This study has focused specifically on a few of the many potential health outcomes to understand what the actual marginal impact of this given schedule of messages could have on the individuals. In turn, this would be an improvement in the field in having a stringent evaluation of the actual impact.

4 Estimated impact

4.1 Assumptions

Some of the assumptions that are core to this analysis include the following:

- The calculations for these interventions are based focused on women who deliver during a year-long intervention period (so the actual intervention period extends to approximately 1.5 years).

- There are 1,026,458 individuals in the target population.

- There are 28,476 deliveries a year in that region and meaning there are 18,918 total women pregnant in a year.

- The maternal mortality rate of the region is 131 maternal deaths for every 100,000 live births and the neonatal mortality of the country is 30 deaths for every 1,000 live births.

- 40% of the people in the target population own phones.

- The cost of a text message is approximately $0.03 and the cost of a voice call is approximately $0.08.

- The GDP per capita is $1,645.52 and the discounting rate used in the following calculations is based on a discount factor of $0.03 and an ideal life expectancy of 83 years.

4.2 Costs

Type of cost	Name of cost	Price	Quantity	Total
Infrastructure	Phones	$10.00	12,000	$120,000
	Mobile infrastructure	$15,000.00	1	$15,000
	Postnatal supplements	$10.00	6,000	$60,000
	Evaluation	$100,000.00	1	$100,000.00
Staffing	CHWs	$1,500	20	$30,000
	Nurses	$2,000	10	$20,000
	Call center	$1,500	15	$22,500
			Total	**$367,500**

Table 2: Fixed costs

Type of cost	Name of cost	Price	Quantity	Total
Text message	Registration/logistics	$0.03	10	$0.30
	Informational	$0.03	400	$12.00
	Reminders	$0.03	200	$6.00
Voice	Questions	$0.08	100	$8.00
			Total	**$26.30**

Table 3: Variable costs

There are two types of costs involved in the implementation of the project: fixed costs (Table 2) and variable costs (Table 3). This is detailed in and can be seen in the equation below, where the cost C is a function of the fixed costs F, the variable costs V, and the number of patients N.

$$C = F(I_P, I_M, I_E, I_S, S_{CHW}, S_N, S_{CC}) + V(M_{SMS}, M_V) \times N \qquad (1)$$

The basic fixed costs include infrastructural I and staffing costs S. The infrastructural costs include the costs for new phones I_P, mobile infrastructures I_M, evaluation I_E, and supplements I_S. The assumption of the calculation for I_P is based on the assumption that 60% of the population does not have a mobile phone, and 60% of the approximately 20,000 pregnant women. The cost for the postnatal supplements is based on the cost of a set of supplement being $0.05 for a day and the entire regimen being 6 months or $30 \times 6 = 180$ days for a total of $10 for the entire regimen. This calculation only includes 6,000 regimens because these are only purchased as an addition to the existing supplies and because the supplements will be used only for women who are at high risk for anemia. The total infrastructural costs come out to $295,000, or approximately $300,000.

The staffing costs including increased staffing for the community health workers S_{CHW}, nurses S_N, and call centers S_{CC}. This is based on a loose assumption of approximately $10 a day for compensation and working 150 days during the year for community health workers and call center workers and $12.50 a day for 160 days a year for the nurses. The total staffing costs comes out to $72,500, which can be rounded up to $100,000 with some leeway for adjustments.

The basic variable costs include the text-message M_{SMS} and voice call M_V charges accrued by the system multiplied by the number of women who are enrolled. With the base costs of the text-messages and voice messages at $0.03 and $0.08 respectively, the entire messaging schedule would cost less than $30 per woman. Since we are assuming 18,918 pregnant woman, the total messaging cost comes out to $567,540, or close to $600,000.

Therefore, the total cost can be calculated to be $I + S + M \times N = \$300,000 + \$100,000 + \$30 \times 20,000 = \$1,000,000$

Overall, the costs for this intervention are very low, specifically because the infrastructural costs are minimal and most of the costs are from the variable costs of text messages, which are very cheap. Therefore, there is very strong potential for a small amount of money to go a long way in this space, which is explored in the section below.

4.3   Targeted Outcomes

The targeted outcomes include aspects of neonatal and maternal mortality related to breastfeeding, neonatal care seeking, and postnatal supplementation. However, since there are few strong and comprehensive studies on the effect of the relatively new mobile technology on health outcomes, many of these estimates are quite approximate.

Looking at the statistics of the region, the infant mortality is 30 deaths for every 1,000 live births in the country, this means in a region with 28,476 deliveries in a year, there are $28,576 \times 30/1,000 = 857.28$ neonatal deaths in a year. A similar calculation can be done with maternal mortality, which is 131 deaths for every 100,000 live births, or $28,576 \times 131/100,000 = 37$ maternal deaths in a year.

NMR reduction	Effectiveness	Lives saved	YLL averted	Lost income averted
55%	20%	94	5,656	$9,307,390
	30%	141	8,484	$13,961,085
	40%	188	11,312	$18,614,780
85%	20%	145	8,741	$14,384,148
	30%	218	13,112	$21,576,222
	40%	291	17,482	$28,768,297

Table 4: Loss of income averted by breastfeeding intervention.

Looking specifically at breastfeeding, studies have shown breastfeeding to effect 55-85% of all-cause neonatal mortality [10]. As seen in Table 4, this means that with a range of 20%, 30% and 40% efficacy of the text messaging based intervention, the range of neonatal deaths reduced can range from 94.27 (11%) -291.38 (34%) deaths from the original [15]. And since breastfeeding only affects deaths as opposed to disabilities, based on the calculation of the years of life lost, this could save between 7824 to 24184 YLLs across the population. The loss of income averted is calculated on the basis of 60 years of life lost at $1,645.52 per year discounted at 3%.

A similar calculation can be done for the other health outcomes, including sepsis and diarrhoea. The framework for doing so would look fairly similar, except using the figures that sepsis contributes to 8% of neonatal deaths and diarrhoea contributes to 7%. While diarrhoea does not have a disability weight, sepsis has a weight of 1, being considered as part of the neonatal deaths. Furthermore, a similar cost calculation can be done for the mothers' risks, including but not limited to anemia and infection.

Other health outcomes that can be measured for potential measurement of impact include the rate at which health-seeking behavior emerges, specifically with regards to neonatal care. Additionally, it would be interesting to get more statistics on usage, including how many questions and what types of questions are asked, as well as feedback on the reception and usability of the entire system. These would be interesting and important in improving this intervention in the future as well as future interventions.

5 Summary and discussion

5.1 Feasibility

While mobile phones are not a solution to poor health, they can serve as a tool that aims to facilitate more effective execution of solutions [16]. The strong reliance on technology that this study has can be both a strength and a weakness. It does leverage some of the growing trends of technological usage and attempts to ameliorate some of the starkest differences in the spread of technological penetration, however, it is difficult to proceed with weak infrastructure. Sometimes with technological solutions, some of the biggest challenges are simple things like being able to charge the battery power or getting connection in a remote part of the village [3]. While this study does allocate some funding towards building up this infrastructure, just a single study is not sufficient to establish the entire infrastructure.

Furthermore, this study by no means makes any claims about technology being able to solve all health problems. This intervention is not meant to be standalone and definitely cannot replace building and strengthening of the health infrastructure. Moreover, this approach should not aim to replace the need for having health workers with a mobile system, rather, should enable the healthcare workers achieve goals they could otherwise not be able to, such as being connected to farther families. It is important to point out the need and importance of nontechnical solutions in conjunction with these technical ideas. For example, simply having communication with a farther woman does not ever mean that road construction should stop! Rather, having more robust roads would increase health access and communication which the mobile-based solutions can build on but never replace.

The merits of other nontechnical solutions should also be mentioned. Health system strengthening could include infrastructure such as building better roads and closer clinics or training and hiring more nurses and doctors to provide care in these hard to reach regions. Specifically with regards to neonatal and maternal care, providing better facilities and options in antenatal, delivery, and postnatal care is important and efforts should also be put into tackling some of the larger problems such as postpartum hemorrhage.

5.2 Long-run impacts

In addition to being cheap for the impact it gives, there are also many other impacts that this proposed intervention can create that are not necessarily monetary or measured in terms of health impact. Some of the additional positive externalities that this program could have include:

- Increasing **access to technology** has many benefits. One of the benefits could be

simple familiarity and literacy with technology. With more use, technology will become more commonplace, allowing the possibilities for innovation and access to information. This study also helps build the technological infrastructure for future studies that will look at the effectiveness of other mobile-based solutions as well as the potential introduction of new technology.

- A problem in rural areas is that it is hard to access healthcare. Mobile technology helps distribute health-related information to harder to reach areas while also strengthening the **communication channel between patient and hospital**. Being receptive to some of the messages provided by healthcare providers, even if they are in popular media form, can help build trust and care on both ends and provide this channel of communication that can be leveraged in the future. These benefits of communication have been demonstrated in previous studies as well [21].

- One weakness of the current deployments of mobile technology are that they have not had a **comprehensive evaluation** in terms of an impact assessment. This study provides the infrastructure for this evaluation and lays the groundwork for specifically analyzing the impact on a small subset of health outcomes that happen to be very important for maternal and child health. Providing the funding and framework for evaluation is important for not only this study but future studies and initiatives as well.

5.3 Future work

There is much room for future expansion for this project as well as for mobile health in general. For example, looking at the schedule of text messages, it would be interesting to integrate psychology in understanding behavior change and whether the timing will effect the acceptance of the messages over time. Another question is looking at the sustainability of the project. While a good cost-effectiveness argument is important for future funding and potential integration into the governmental health system, other forms of funding should be explored. One potential option is having company sponsor the text messages, whether they are relevant ads for, say, diapers, or other telecom companies.

Technology is the future and it is important to understand the implications of such innovations and developments on healthcare in a variety of settings. This has proven to be an interesting analysis of the potential for the technical solution to have on health outcomes. However, the field is still young and growing, meaning that there is more to be developed on the technology side and much, much more to understand on the outcomes side as well.

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