Impact of a Community-based Smartphone Intervention on Maternal Health Service Utilization in Rural Tanzania

by

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Dalla Lana School of Public Health
University of Toronto

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Abstract

Improving access to safe facility-based delivery (FBD) is a challenge in rural Tanzania, where 50% of women deliver at home without skilled medical assistance. Community health workers (CHWs) may improve women’s demand for, and uptake of FBD services; however CHW performance can be suboptimal without supportive supervision and job aids. This dissertation addresses key questions in maternal health services research and contributes to the evidence base for mobile health (“mHealth”), for which rigorous impact studies in low-income countries remain scarce.

This study employed a cluster-randomized, controlled, mixed-methods trial design to evaluate the impact of a smartphone-based intervention (SP+) designed to assist CHWs with data collection, prenatal education delivery, gestational danger sign identification, and referral on women clients’ utilization of FBD. Pairs of CHWs in 32 villages were cluster-randomized to receive training on either SP+ or standard, paper-based protocols for use during household visits with clients. The main outcome (delivery location) was ascertained via postnatal household surveys with 572 randomly selected women. In-depth qualitative interviews with 60 CHWs and
14 healthcare professionals, and focus group discussions with 56 women clients were conducted to explore perceptions of CHW performance, quality of care, and SP+ implementation strength.

SP+ was associated with increased FBD: after adjusted analyses, the odds of FBD in intervention villages were two times greater than the odds in control villages (OR=1.95; p=0.02). A key underlying mechanism was increased household visit frequency by smartphone-assisted CHWs; these CHWs reported higher job satisfaction compared to peers in the control group. Qualitative findings suggest that SP+ led to perceived improvements in data management, communication, decision-making support, emergency response, enhanced social status and credibility, and perceived health system improvements among clients. However, concerns regarding privacy and data security were raised.

Through triangulation of methods and data sources, I demonstrate how factors influencing women’s use of FBD in this context are multidimensional and thus require multi-level maternal health programs and policies. I argue that while SP support for CHWs can be efficacious in targeting increased FBD, prevailing health system weaknesses including a lack of formal support for CHWs limits the potential impact of such strategies.
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“The death of Mothers! The death of Children!
What is this? Unacceptable!”

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Chapter 1
Context and Relevance

Maternal, newborn and child health globally

In recent decades, efforts to improve maternal, newborn and child health (MNCH) have drastically increased due to the renewed momentum of the safe motherhood movement and a global commitment to achieve the Millennium Development Goals (MDGs). Of particular relevance are MDG 4 (to reduce child mortality rates by two thirds between 1990 and 2015) and MDG 5 (to improve maternal health by i. reducing maternal mortality rates by three quarters, and ii. achieving universal access to reproductive health by 2015) (Sachs and McArthur 2005). Improvements can be seen in the 45% reduction in the global maternal mortality ratio (deaths per 100,000 live births) since 1990, and the decreased mortality rate for children under five (down more than 50% over the same period) (United Nations 2015). Despite these encouraging trends, progress has been slow in sub-Saharan Africa and South Asia, which together account for over 85% of maternal deaths (United Nations 2015). Skilled birth attendance, a widely acknowledged proximate determinant of maternal survival, increased only modestly over the past few decades in sub-Saharan Africa, from 40% to 53% (Fotso and Fogarty 2015). Further, Hogan et al (2010) reported a 23% to 52% increase in the proportion of global maternal deaths that occurred in sub-Saharan Africa between 1980 and 2010. As we enter a new global development agenda – guided by the Sustainable Development Goals (SDGs) – it is pertinent to learn from the laudable gains made globally to improve and achieve equity in MNCH outcomes across and within LMICs, particularly in sub-Saharan Africa.

Ensuring the health of women and children is dependent on the availability and use of safe, adequate health services along a continuum of care - during adolescence, pregnancy, childbirth, the postnatal period and throughout childhood (Kerber et al. 2007; Victora et al. 2003). Consequently, strengthening health systems to improve access to health services, and preventing the leading illnesses affecting women and children are major priorities for low and middle-income countries (LMICs). Most maternal deaths result from preventable causes such as hemorrhage, hypertensive disorders and sepsis, and could be averted through delivery of proven intervention packages throughout pregnancy, labour and delivery (Say et al. 2014). The provision of appropriate medical care during pregnancy, and the attendance of skilled health
personnel during labour and delivery are crucial if perinatal, neonatal and maternal deaths are to be reduced.

The World Health Organization (WHO) recommends that all pregnant women receive a minimum of four antenatal care (ANC) check-ups. The prenatal period is an important entry point into the health system, particularly for women in rural areas because it facilitates access to medical personnel and health information for future maternal and child health needs (Gage 2007). Standard ANC visits should include, at minimum, measurement of maternal blood pressure and management of pre-eclampsia, testing of urine for bacteriuria and proteinuria, at least two doses of tetanus toxoid vaccination, and testing of blood for conditions such as syphilis and severe anemia (World Health Organization 2003). Crucially, ANC visits provide an opportunity to screen women for obstetric complications, and facilitate counselling on risk factors during pregnancy, labour, and delivery. Health workers also use ANC visits to encourage women and their families to develop delivery plans in advance, and to promote clean and safe deliveries, ideally with trained assistance (Bloom, Lippeveld, and Wypij 1999). However, in LMICs, these prescriptions are rarely met consistently and inequities in access to maternal health care persist.

Studies from a diverse range of geographical contexts suggest that inequities in access to maternal healthcare exist not only between rich and poor countries, but also within LMICs (Magadi, Zulu, and Brockerhoff 2003; Pallikadavath, Foss, and Stones 2004; Collin, Anwar, and Ronnsmans 2007; Silal et al. 2012). Gwatkin and colleagues (2004) analyzed pooled data from demographic health surveys in 50 developing and transitional countries and found that antenatal care coverage reached almost 90% in the highest wealth quintiles but less than 60% within the lowest wealth quintiles. Disparities in skilled delivery were even greater, with coverage of about 90% among those in the top wealth quintiles, and less than 35% in the poorest quintiles (Gwatkin, Bhuiya, and Victora 2004). Depending on the context, this problem may be rooted in a combination of factors ranging from low service availability and coverage in the poorest, most remote areas of LMICs, to poor quality of care and preferences for alternate systems of healing.

Ensuring that all women receive timely, quality health care throughout pregnancy, childbirth and the postpartum period is challenging in settings where health systems are chronically underfunded and human resources for health are constrained. The shortage and inequitable
distribution of midwives, nurses, and physicians in LMICs is especially problematic, as people living in rural or otherwise hard-to-reach communities are unable to access services and medications when they need them (Global Health Workforce Alliance and World Health Organization 2010). To overcome this, currently available human resources must be identified and utilized in the most effective and efficient ways possible.

In LMICs, community health workers (CHWs), frontline health workers who deliver basic medical services and health promotion, have been trained and deployed to address various gaps in MNCH services. While they cannot completely replace highly skilled health care professionals, CHWs have the ability to strengthen linkages between communities and the formal health care system. CHWs with relevant knowledge, experience and skills can play an integral role in improving maternal and child survival through mobilization of communities, promotion of healthy nutrition and care behaviours, management of childhood illnesses, and delivery of preventive health education and services (Bhutta et al. 2011; Haines et al. 2007; Huicho et al. 2008). CHWs can also help to improve MNCH by supporting the provision of postnatal services that target nutrition, infant survival, HIV and other infectious diseases, and women’s reproductive health issues (Baqui et al. 2008).

There is tremendous potential for CHWs to strengthen health systems by enhancing women’s access to maternity services during pregnancy, which are commonly available in LMICs but often underutilized. However, in order to maximize the effectiveness and efficiency of CHWs, there is a need for additional research on ways to strengthen the links between the formal health system, CHWs, and the clients they serve. Tanzania has a long history of training and deploying frontline health workers, with varying levels of success, making it a particularly relevant and timely context to study CHWs’ role in improving maternal health.

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1 According to the World Health Organization, CHWs “should be members of the communities where they work, should be selected by the communities, should be answerable to the communities for their activities, should be supported by the health system but not necessarily a part of its organization, and have shorter training than professional workers” (WHO 1978).
The Tanzanian context

Tanzania has been identified as a priority country for multiple bilateral aid and development investments, and the Government of Canada is a major donor. At the 2010 G8 summit\(^2\), Canada announced its Muskoka Initiative, a pledge to invest over 1 billion dollars in new funding to support MNCH activities. The aim of this initiative was to accelerate progress towards achieving MDGs 4 and 5 in ten developing countries; Tanzania received the largest proportion of funds at $143 million (Bhushan 2014). Canada leverages strategic partnerships with the Tanzanian Government, multilateral agencies, civil society organizations and other donor countries “to promote Canadian values of democracy, rule of law, respect for human rights, and compassion for the less fortunate” (Global Affairs Canada 2015). MNCH, health systems and HIV/AIDS are three specific priority themes emphasized by Global Affairs Canada and its implementing partners in Tanzania, and values such as gender equity and women’s empowerment feature prominently in Canadian-funded development frameworks.

Tanzania has made impressive progress in reducing under-five mortality – in 2013 Tanzania successfully reached its MDG 4 target to cut 1990 rates by 50 percent (Afnan-Holmes et al. 2015). Despite this reduction, gains in maternal health have been relatively stagnant and the maternal mortality ratio remains unacceptably high at 410 deaths per 100,000 live births (WHO et al. 2014). Part of this problem is that inequities in coverage and uptake of maternal health services continue to persist. For example, while 88% of women receive at least one antenatal check-up, only 43% receive the recommended four ANC visits (World Health Organization 2012). Skilled birth attendance is also low in Tanzania: only about half of all women deliver babies in a health facility with a trained health professional (Afnan-Holmes et al. 2015). Further, women are encouraged to seek ANC before the 16\(^{th}\) week of gestation and while the costs of these services are covered by a national health insurance plan, more than 80% of pregnant women initiate ANC later than 17 weeks gestation (Mrisho et al. 2009). These figures are countrywide estimates, and in many rural areas where trained health professionals are scarce, the proportion of women who receive timely, appropriate maternal health services is much

\(^2\) The Group of Eight (G8) refers to eight highly industrialized nations (France, Germany, Italy, the United Kingdom, Japan, the United States, Canada, and Russia). The group holds an annual meeting to discuss pressing international issues, including global health and development.
Research in other LMICs suggests that women residing in rural areas tend to seek ANC later, attend fewer ANC visits and receive fewer services than women living in wealthier urban centres (Tran et al. 2011).

**CHWs in Tanzania**

Due to Tanzania’s fragmented health infrastructure and with 68% of its population living in rural areas (The World Bank 2016), CHWs are essential to improving MNCH in this context. Following the adoption of the Alma Ata Declaration (WHO 1978) by the global health community in 1978, CHWs were considered the foundation of primary health care in many countries (Bhutta et al. 2010). In Tanzania, CHW programs were widespread in the 1980’s, as such programs coincided with early post-independence efforts to achieve decolonization and President Nyerere’s national social and economic policy, *Ujamaa*³ (*familyhood* in Swahili) (Haines et al. 2007). This policy aimed to create “rural economic and social communities where people would live together for the good of all” (Nyrere 1968, cited in Ibhawoh and Dibua 2003, p. 67). In keeping with values of the primary health care movement, CHWs were not only promoted as valuable health care providers, but also as advocates for community justice and agents of social change. CHWs functioned as liberators of community rights and needs, and provided a voice to those who historically were not included in health policymaking (Haines et al. 2007).

Many of Tanzania’s frontline CHWs have been active for decades, however levels of activity, experience, training and expectations vary widely. National recommendations are for each village health committee to appoint at a minimum two CHWs, and these individuals can be male or female. Members of the community should be responsible for electing CHWs, and they are expected to work on a voluntary basis. While the government acknowledges the inherent value of CHWs, there is currently no nationwide policy in place to formally recognize or pay them, although discussions regarding a new cadre of paid CHWs are ongoing (Mpembeni et al. 2015).

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³ Ujamaa was one of the key parameters outlined in the historical Arusha Declaration in 1967, and is widely understood as a core guiding principle behind Nyrere’s approach to Tanzania’s development. The Arusha Declaration emphasized the importance of “self-reliance” (*kujitegemea* in Kiswahili). This ideology rested on the proclamation that the best way for Tanzania to achieve rural development was to “rely on its own resources, land, and people”, rather than on external aid (Schneider 2004).
At the time of the present study, the Tanzania Ministry of Health and Social Welfare (MoHSW) had shifted decision-making responsibilities regarding management and incentivization of CHWs to district level health management teams, and the cost of training and monitoring CHWs currently falls to NGOs operating across the country.

Both the MoHSW and local and international NGOs work with and rely on CHWs, occasionally recruiting them to participate in health promotion campaigns and training seminars on specific health topics. As a result, CHWs belong to a rather precarious workforce, with limited government-sanctioned support or job security. With the recent influx of international donor funds and programs for MNCH, a surplus of NGOs work to leverage CHWs to achieve program targets. In the absence of a formal support system for CHWs, many of these programs are experimenting with novel technologies and other means of support to manage and incentivize CHWs. As such, there is a need for rigorous evaluation research by external partners to ensure that what is being implemented has a positive impact on CHWs as well as key MNCH indicators.

**Research Problem & Rationale**

While the potential exists for CHWs to improve MNCH outcomes, a number of substantial challenges with the CHW model persist. In the absence of sufficient training, effective supervision and job aids, CHW performance can be suboptimal, characterized by high error rates and low protocol compliance, even when provided with paper-based clinical guidelines (Florez-Arango et al. 2011). Issues with equity of service delivery, training and supervision, incentives, attrition, record keeping and information management are the subjects of ongoing discussion and debate among policy makers, both globally and within Tanzania. In order to improve the quality of CHW care, decrease CHW attrition rates, and ultimately improve MNCH outcomes, innovative strategies are needed to strengthen the link between CHWs, their support network, and their clients.

The relatively new field of mobile health (often referred to as ‘mHealth’) has garnered much attention globally for its potential to augment health system shortfalls and help address many of the challenges with CHW programs (Agarwal et al. 2015). Interventions combining the use of CHW services and mobile phone-based technologies have the potential to synergistically improve women’s access to health services as devices may enable CHWs to reach more women,
improve follow up and provide tailored counselling. While mobile phones are considered a promising tool for CHWs, rigorous scientific studies evaluating their impact are currently limited (Agarwal et al. 2015). There is a need to build a more robust evidence base for mHealth strategies before broad funding and policy decisions can be made. This dissertation aims to help fill this gap by focusing on the intersection of three interrelated domains of health services research: access to maternal health services, community health workers, and mHealth technology (Figure 2). The specific objective was to investigate whether, and how, a smartphone-based job aid used by CHWs improves women’s uptake of facility-based delivery and other maternal health services in rural Tanzania.

Figure 1: Intersecting research domains investigated in this study
Chapter 2
Literature Review

Maternal healthcare access in LMICs

Access vs. Utilization

Access to healthcare is a complex concept, and myriad frameworks aiming to delineate its dimensions have been published (see Levesque, Harris, and Russell 2013; Obrist et al. 2007; O'Donnell 2007; Balabanova et al. 2006; Jacobs et al. 2012; Aday and Andersen 1974). Consequently, there is no universally accepted definition of access. Many authors conflate access with utilization, or use the terms interchangeably, however it is important to acknowledge that they are conceptually very different. For example, some authors have defined access as “the timely use of service according to need” (Jacobs et al. 2012; Peters et al. 2008), however I would argue that this definition more accurately describes utilization. Thiede (2005) presents a more nuanced perspective, offering that access should be seen as a precondition to health service utilization and consequently, utilization should not be used as a proxy for access.

Obrist and colleagues (2007) note that even when services are technically available, affordable, adequate in terms of quality, and acceptable to clients, utilization rates can be highly variable. Thus, while women in a given community may technically have access to maternal health services (measured by the number and proximity of health facilities and medical personnel in their locality, for example), they may not necessarily utilize these services for various reasons. Often cited individual and household-level barriers include socioeconomic constraints, gender effects on health seeking behaviour, stigma associated with health seeking, and cultural beliefs about pregnancy and childbirth (Travis et al. 2004; Simkhada et al. 2008). At the community level, there may be an absence of social pressures to improve utilization of maternal health services (Travis et al. 2004; Titailey et al. 2010b).

Following this rationale, if one has access to healthcare, this means that opportunity for utilization exists. Thiede (2008) extends this line of thinking and posits that the best definition of access is not the potential to utilize, but rather the freedom to utilize. For individuals who have access to healthcare there exists both social possibility and the individual ability to act on their desire to use healthcare services. Thiede reasons that in order for health systems to function
well, health services must not only be medically secure but also culturally secure. Thus, according to Thiede’s definition of access, antenatal and obstetric services must do more than fulfil the proper criteria of medical quality; they must also incorporate women’s cultural expectations of maternal health care.

Factors affecting maternal health service utilization

The literature on the factors influencing women’s utilization of maternal healthcare has grown exponentially over the past decade. This proliferation of studies coincided with the 2015 Millennium Development Goal deadline. MGD 5, to reduce maternal mortality, prioritized two key health services indicators: 1) proportion of deliveries attended by skilled health personnel; and 2) antenatal care coverage. As a result, the majority of research in this area has focused on identifying individual, household, and community-level predictors of antenatal care (ANC) and skilled/facility-based delivery uptake in LMICs. An abundance of both qualitative and quantitative studies are currently available; key findings are summarized below.

Geographical and financial barriers to maternal health service access are widely acknowledged across studies in LMICs (Ensor and Cooper 2004; Peters et al. 2008). Socioeconomic status in particular is a key predictor of maternal health service uptake, and cost is one of the most commonly cited barriers across settings (Wilunda et al. 2014; Tey and Lai 2013). While many public health systems offer free pregnancy and delivery services, utilizing care can still be quite expensive, due to both direct and indirect costs associated with transportation, time away from income-generating activities, and unofficial provider payments, for example (Bohren et al. 2014; Jacobs et al. 2012). Despite this, cost is not always an insurmountable obstacle. A study in Tanzania found that many women prefer to deliver in mission facilities, which tend to be of higher quality but charge out-of-pocket service fees (Kruk et al. 2008). Almost half of the women in this study reported reducing spending, borrowing money, or selling household assets to cover delivery costs, and this was most frequently reported by the poor. Another Tanzanian study found that low-income women avoided seeking antenatal care services out of fear of discrimination by wealthier health professionals in clinics (Kowalewski, Jahn, and Kimatta 2000). Low-income women also had very different perceptions of what constitutes “high risk” pregnancies. These findings suggest that while a mere shortage of funds to pay for direct and
indirect costs may prevent some women from utilizing services, class differences and differential social status also have an impact on service uptake.

Other predictors of service utilization during pregnancy and childbirth include: maternal age, education, occupation, religion, parity, health literacy, marital status, perceived quality of health care services, having a history of obstetric complications, and distance and travel times to clinics (World Health Organization 2003; Spangler and Bloom 2010; Falkingham 2003; Fotso et al. 2009; Simkhada et al. 2008; Kruk et al. 2010; Glei, Goldman, and Rodriguez 2003). Although these variables have consistently been linked to maternal health care utilization in various settings, the pattern and magnitude of these relationships vary between countries, thus geographical and cultural differences are also thought to play important roles in mediating maternal health seeking behaviour (Stephenson et al. 2006). For example, maternal age at marriage tends to be positively associated with ANC attendance (Mahabub-Ul-Anwar, Rob, and Talukder 2006), however the evidence is inconsistent and contradictory findings have also been reported (Simkhada et al. 2008). Age at marriage was positively correlated with ANC attendance in India and similarly, in Nepal, women who married after the age of 19 were more likely to utilize ANC services than peers who married younger (Pallikadavath, Foss, and Stones 2004; Ensor and Ronoh 2005). Correlations between maternal age at pregnancy and utilization of skilled delivery are also inconsistent. While some studies report that younger maternal age is positively associated with facility-based delivery (Mpembeni et al. 2007; van Eijk et al. 2006), others have reported that older mothers are more likely to deliver in facilities with trained attendants (Yanagisawa, Oum, and Wakai 2006). Both ANC utilization and skilled delivery tend to be negatively associated with parity (Spangler and Bloom 2010; van Eijk et al. 2006; Yanagisawa, Oum, and Wakai 2006; Ali et al. 2010).

Research in Kenya found that ANC was utilized less frequently when pregnancies were unwanted or mistimed (Fotso et al. 2009; Magadi, Madise, and Rodrigues 2000). Increased distance or travel time to the nearest clinic was associated with poorer ANC attendance and facility-based delivery in both Kenya (van Eijk et al. 2006; Magadi, Madise, and Rodrigues 2000) and India (Nielsen et al. 2001). Further, the likelihood of delivering in a health facility tends to be higher among women who come into contact with a skilled birth attendant during antenatal care (Yanagisawa, Oum, and Wakai 2006). In another Kenyan study, women’s decision to deliver in a health facility depended on whether they were advised to do so during
ANC visits (Fotso et al. 2009), which illustrates why efforts to improve facility-based delivery often focus on encouraging women to attend regular ANC visits leading up to childbirth. In a Tanzanian survey, reasons reported for choosing home delivery included fear of being referred to a hospital, and having readily accessible traditional birth attendants (Mpembeni et al. 2007). A more recent study in Tanzania found that even women who were able to attend ANC appointments were unsatisfied and reluctant to return due to a lack of services and insufficient staff available to provide appropriate care (Gross et al. 2012).

In many countries, both maternal education and women’s husband/partner’s education consistently exhibit positive relationships with ANC attendance and skilled delivery uptake (Pallikadavath, Foss, and Stones 2004; Spangler and Bloom 2010; Simkhada et al. 2008; van Eijk et al. 2006; Ali et al. 2010; Raghupathy 1996). A study in Tanzania found that low levels of support from husbands/partners during pregnancy were significantly associated with later antenatal care enrolment among women (Gross et al. 2012). Research in Zimbabwe (Kambarami, Chirenje, and Rusakaniko 1999) and Nigeria (Adamu and Salihu 2002) found that husbands played an important role in determining whether women utilized ANC services, however a study in Kenya found that women made health-seeking decisions independently (van Eijk et al. 2006). A randomized controlled trial in Nepal found that educating both pregnant women and their male partners together resulted in a greater net impact on maternal health seeking behaviours compared to educating women alone (Mullany, Becker, and Hindin 2007). Demographic indicators at the community level (e.g. proportion of women with secondary education, percentage of husbands in a community who approve of family planning) have also been positively associated with facility-based delivery, while average parity in a given community is negatively associated with skilled delivery (Stephenson et al. 2006).

Qualitative studies illustrate that health seeking during pregnancy may be influenced by a woman’s perceived self-efficacy\(^4\), her autonomy and decision-making power, degree of partner support, perceived quality of clinical care, family members’ attitudes towards available services, and previous experience with the formal health care system (Amooti-Kaguna and Nuwaha 2000;  

\(^4\) Self-efficacy is defined as beliefs in one’s capabilities to organize and execute the courses of action required to produce a given attainment; in this case a woman’s perceived ability to access and utilize health services (Bandura and Locke 2003).
Kowalewski, Jahn, and Kimatta 2000; Cham, Sundby, and Vangen 2005; Lubbock and Stephenson 2008). The important role of women’s autonomy has been confirmed in quantitative research as well. A study in India found that women with greater freedom of movement\(^5\) utilized higher levels of ANC and were more likely to obtain safe delivery care (Bloom, Wypij, and Das Gupta 2001). These researchers suggest that women’s autonomy may be just as important as other known determinants of maternal health care uptake.

Ethnographic research demonstrates how social norms surrounding pregnancy and childbirth are culture-specific and therefore highly variable between contexts (Jordan 1978). As such, community perceptions are particularly important determinants of maternal health service utilization. For example, a large survey study in Tanzania emphasized the critical role of women’s social worlds, reporting that community opinions regarding the quality of the health system influenced women’s delivery locations (Kruk et al. 2010). In southern Tanzania, researchers found that ANC utilization was strongly dependent on community perceptions of danger signs during pregnancy and delivery (Kowalewski, Jahn, and Kimatta 2000). Mismatches between biomedical and community perceptions of risks led to utilization of different treatment options ranging from biomedical services to traditional healing methods.

Western perspectives tend to medicalize pregnancy and childbirth by treating these periods as problematic, and needy of biomedical intervention. However, this conceptualization is far from universal; in many settings, pregnancy and childbirth are not considered medical states at all, and therefore clinical interventions such as ANC and obstetric care may be deemed unnecessary and even undesirable (Costello and Manandhar 2000). In many contexts, a commonly reported perception is that only complicated or unusual pregnancies and births require medical intervention. A study in Indonesia reported low community awareness regarding the importance of prenatal and obstetric services, and a common perception that these services were unnecessary in the absence of complications (Titaley et al. 2010a). Similarly, women in Uganda expressed the belief that only abnormal pregnancies should be handled in health facilities (Parkhurst, Rahman, and Ssengooba 2006). In Bangladesh, an anthropological study found that

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\(^5\) Measured using a multidimensional index based on four items: women’s ability to leave the house alone (1) to go to the market, (2) to take her child to the doctor, (3) to go to the doctor for her own healthcare, and (4) to visit family members when they wished (respondents were scored from 0-4).
rural women who sought assistance during childbirth at home, or those who chose to deliver at a facility, were ostracized by their peers because it was assumed that these women had done something to cause complications in the first place (Afsana and Rashid 2000). Another Ugandan study found that women viewed pregnancy as a natural test of endurance and strength and thus women who delivered on their own were highly regarded by their communities (Kyomuhendo 2003). In rural Zimbabwe, researchers documented a widely held belief that during early pregnancy, women are particularly vulnerable to the influence of witchcraft (Mathole et al. 2004). As a result of this belief, women perceived early ANC seeking as a potentially dangerous practice.

Arthur Kleinman’s theoretical work on client/provider interactions is of relevance here. According to Kleinman, explanatory models (EMs) “are the notions about an episode of sickness and its treatment” (pp. 105) and are held by patients and practitioners in all health care systems (Kleinman 1980). EMs are culture-dependent and are reflective of particular illness episodes or corporal states. As such, women in different contexts will have particular EMs of both pregnancy and childbirth. Importantly, interactions between patients’ EMs and those of practitioners are critical factors influencing the nature of patients’ sickness and healing experiences (Kleinman 1980). When there is low concordance between women’s explanatory models and those of their healthcare providers, patients’ experiences of clinical interactions are likely to be negative, and thus they may be less inclined to seek future care. Lack of agreement between explanatory models can persist as a result of cultural, ethnic, or class disparities between patients and providers (Kleinman 1980).

The concept of explanatory models is intrinsically linked to Brigitte Jordan’s (1980) notion of authoritative knowledge. As Jordan explains:

“For any particular domain, several knowledge systems exist, some of which, by consensus, come to carry more weight than others, either because they explain the state of the world better for the purposes at hand, or because they are associated with a stronger power base” (p.152).

Within the domains of pregnancy and childbirth, the biomedical paradigm has become the most dominant and most legitimized knowledge system among healthcare providers and thus, ANC and skilled delivery are structured to reflect this way of knowing (Spangler and Bloom 2010).
However, patients may not share the same beliefs as their healthcare providers; in many countries in sub-Saharan Africa, women commonly rely on traditional forms knowledge regarding pregnancy and childbirth, or a combination of several forms of knowledge (Wiley 2002). As such, some women may reject dominant biomedical interpretations of pregnancy and birth and may find it difficult to build meaningful relationships with clinicians who emphasize biomedical approaches. The use and application of authoritative knowledge during a clinical encounter can lead to power differentials between patients and providers. These power imbalances may become barriers to access, discouraging women from seeking ANC and skilled delivery.

Several studies have explored how household gender dynamics influence maternal health service utilization. For example, ethnographic research in Pakistan found that pregnancy-related decisions are most commonly made by older women (usually mothers-in-law) and sometimes by male family members who are older than the husband (Mumtaz and Salway 2007). In this context, both pregnant women and their husbands were the parties most removed from the decision-making process. Qualitative research in rural Gambia (Cham, Sundby, and Vangen 2005) reported similar findings. In contrast, in both Bangladesh and Uganda, male partners appear to be the main decision-makers with respect to utilization of both ANC and obstetric services (55). Taken together, these results highlight the importance of understanding household gender dynamics in different contexts; as such interactions are likely to impact on women’s decision-making power with respect to maternal healthcare utilization.

According to Spangler and Bloom (2010), additional qualitative research is needed to unpack the roles of women’s satisfaction with maternity services, women’s autonomy, and gender roles in decision-making with respect to obstetric care utilization. As Simkhada et al. (2008) note in their systematic review, adequate utilization of maternal health services in LMICs will not be achieved by merely increasing the number of health facilities available to women. Rather, the social, political and economic contexts impacting women must be better understood in order to design facilities and health systems that enable women to access health services.

### Common Approaches to Improve Maternal Healthcare Access

Borrowing from basic economic theory, the literature on interventions to improve maternal healthcare access commonly applies a ‘supply and demand’ framework (Levesque, Harris, and
Russell 2013). The basic premise of this framework is that in order to strengthen community health systems, both the supply of health services and the demand for these services must be considered. In general, supply-based approaches attempt to improve access to health services, while demand-based approaches address utilization. Further, the various facilitators and barriers to access and utilization can be related to either the supply (health systems) side or the demand (client) side. Differentiation of demand-side from supply-side factors stems from the need to identify potential points for intervention (Jacobs et al. 2012) however it has been argued that both sides need to be addressed concurrently in order to significantly improve maternal and child health outcomes (O'Donnell 2007).

The dominant research approach within the literature on women’s access to healthcare focuses on the delivery of health services. In this approach, both supply and demand side barriers to access are considered, and access tends to be used as a proxy for utilization (Michielsen et al. 2011). Though a number of frameworks have been proposed in different settings, researchers typically focus on five dimensions of access that are inherent to the health system: availability, accessibility, affordability, adequacy, and acceptability. These dimensions are defined, along with hypothetical examples of barriers within the context of facility-based delivery in Table 1.
Table 1. Five dimensions of access to health care services*

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Definition</th>
<th>Examples of barriers to facility-based delivery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability</td>
<td>The existing health services and supplies meet clients’ needs.</td>
<td>Lack of clean/sterilized obstetric tools in health facilities</td>
</tr>
<tr>
<td>Accessibility</td>
<td>The location of medical services/supplies is in line with the location of clients.</td>
<td>Long distance between households and nearest health facility; scarce transportation options</td>
</tr>
<tr>
<td>Affordability</td>
<td>The prices of services fit the clients’ income and ability to pay.</td>
<td>Service fees unrealistically high; transportation costs too high; unsolicited fees charged by service providers</td>
</tr>
<tr>
<td>Adequacy</td>
<td>The organization of health care meets the clients’ expectations.</td>
<td>The quality of available ANC/obstetric services provided is perceived by clients to be low</td>
</tr>
<tr>
<td>Acceptability</td>
<td>The characteristics of providers match with those of the clients.</td>
<td>Large social distance between provider and patient due to differences in social status, ethnicity, gender, native language, etc.</td>
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*Adapted from Obrist et al. (2007)

Supply-side interventions are those that target health service personnel, health institutions or ministries of health (De Brouwere, Richard, and Witter 2010). Such interventions include increasing the number of health facilities, increasing the availability of medical equipment, increasing the number of qualified health personnel, improving staff skills, and improving diagnosis protocols, treatment, and quality of care (Obrist et al. 2007). One of the most common supply-side health services interventions is to improve the reach of available human resources for health (Balabanova et al. 2006). CHWs are of particular interest here, given their potential to mobilize communities. CHWs can be utilized to improve linkages between households and health facilities, and to increase women’s demand for care and improve access to maternal health services through communication and referral systems (Kerber et al. 2007).

Demand-side interventions are those that operate at the individual, household or community level (Ensor and Cooper 2004). On the demand side of the health services approach,
interventions can be designed to increase patients’ ability to use health services. Improving transportation, providing healthcare subsidies to women to offset the asymmetric control over household resources by male family members, or delivering awareness campaigns to improve patients’ health literacy are all examples of demand-side interventions. Demand-side interventions have been criticized because they tend to be limited to basic information, education, and communication (IEC) campaigns (Obrist et al. 2007) or they focus solely on financing the demand-side of utilization via health insurance provision or community health voucher programs (Michielsen et al. 2011).

The major weakness of health services approaches is that they tend to overlook the complexity of health seeking processes. Other factors known to influence health service utilization, including patients’ trust in healthcare providers, and stigma associated with certain illnesses are also missing from the health services framework (Jacobs et al. 2012). Interventions tend to be rather mechanical in nature, neglecting social aspects of health systems functioning. By focusing only on service barriers to access, this perspective views healthcare underutilization as a one-dimensional problem and makes implicit assumptions about the intentions and behaviours of both service providers and service users; that is, if we increase the amount of services available, then individuals will certainly utilize them. However, we cannot assume that health service users are empty vessels, waiting to be filled with education or provided with financial aid (Penn-Kekana, McPake, and Parkhurst 2007). Improving the capacity of health systems to reach the rural poor (i.e. by increasing the availability of staff, infrastructure and pharmaceuticals) is certainly a crucial step towards improving health service utilization (Balabanova et al. 2006). However, it is equally pertinent to understand the complex dynamics of women’s health seeking, including how it can be shaped by both social and clinical interactions (Mrisho et al. 2007; Shaikh and Hatcher 2005).

History and overview of CHW programs

An increasingly common strategy to address gaps in health service provision and uptake is through the use of lay community health workers (CHWs). Lewin et al (2010) define CHWs as “any health worker carrying out functions related to health care delivery; trained in some way in the context of the intervention, and having no formal professional or paraprofessional certificate or degree in tertiary education”. In essence, CHWs are local community members (usually
elected by their peers) who have received some training in health promotion and basic health services, and whose services are intended to complement rather than replace those of health professionals (The Earth Institute CHW Technical Taskforce 2011). Globally, CHWs are trained to deliver a diverse set of health-related services through national government-supported initiatives and campaigns, or through programs delivered by non-governmental organizations (NGOs). Skills and training foci vary between countries, however a majority of programs in LMICs focus on MNCH-related initiatives (Global Health Workforce Alliance and World Health Organization 2010).

Currently there are various cadres of CHWs in LMICs; some are paid and incorporated into formal health systems, while others are volunteers who may receive small financial or social incentives in return for their services. The most common level of community-based health workers are known as village health workers, community resource people, or workers known by other local names (e.g. Shastho Shebikas in Bangladesh, Lady Health Workers in Pakistan, Community Health Agents in Ethiopia) (Lewin et al. 2010). Other more specialized cadres are equipped to address specific health concerns within their communities, but still have no formal training or certification. Examples of specialized cadres include community rehabilitation facilitators, HIV/AIDS educators, and traditional birth attendants (Haines et al. 2007).

Whether specialized or not, CHWs are members of the communities in which they work and are therefore ethnically, linguistically, socioeconomically, and experientially similar to the clients they serve (Love, Gardner, and Legion 1997). Other auxiliary or mid-level community health personnel such as nurse aides, medical assistants, and physician assistants differ from CHWs because they tend to be integrated into the formal health system, receive longer periods of training, and for the most part work only in health facilities (Haines et al. 2007).

A recent review estimates that outside of the United States, there are more than 4 million CHWs, and 2.3 million of them can be found in India alone (Perry, Zulliger, and Rogers 2014). Both men and women can serve as CHWs, depending on the context and aim of the program, however in a review of 17 articles that specified the gender of CHWs, 70% were female, 12% were male, and 18% included both male and female CHWs (Lehmann and Sanders 2007). In some contexts (such as Bangladesh, for example), CHWs who are recruited and trained specifically to address MNCH tend to be female, married, have children of their own, and can
therefore draw on personal experiences to better relate to the women and mothers with whom they work (Rahman et al. 2010b).

The strategy of using community members to deliver basic health services to their peers is not new, and in fact the CHW platform dates back more than half a decade. The most widely acknowledged early initiative was China’s nation-wide barefoot doctor program from the 1950s to the 1970s (Lehmann and Sanders 2007). Barefoot doctors were rural farmers who received short-term medical training from the government, then returned to their villages to provide basic preventive and curative health services to their community members. The aim of this program was to provide timely medical treatment to rural communities and to reduce financial burden on the health system (Li et al. 2012). In the 1960s and 1970s, following success of the barefoot doctors movement, small CHW programs surfaced in a number of countries, particularly in Latin America (Perry, Zulliger, and Rogers 2014).

China’s barefoot doctor approach and the CHW programs that followed were a major stimulus for the primary health care movement in the late seventies. Following adoption of the Alma Ata Declaration6 by the global health community in 1978, CHWs were touted as the foundation of primary health care systems across the globe (Global Health Workforce Alliance and World Health Organization 2010).

According to Haines and colleagues (2007), the global economic recession of the 1980’s led to major shifts in policy “as the focus on liberation, decolonization, democratization, self-reliance and the ‘basic needs’ approach to development was replaced by World Bank-driven policies of structural adjustment and its successors” (p. 5). Structural adjustment programs (SAP) inevitably led to cuts in funding for social programs including those involving CHWs. Attention to the CHW approach declined as a result of these changes, and LMICs subsequently witnessed a shift towards vertical health service delivery models in the 1990’s (Standing and Chowdhury 2008). Decreased enthusiasm for CHWs was further facilitated by widespread doubt regarding the sustainability of CHW programs, and the perceived success of vertical programming

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6 The Declaration of Alma-Ata emerged as an output of the International Conference on Primary Healthcare at Alma-Ata, Kazakhstan, which was convened by the WHO and UNICEF. The declaration called for the “achievement of Health for All by the year 2000 through primary health care” (Perry, Zulliger, and Rogers 2014).
supported by international donors during the nineties (Haines et al. 2007). Furthermore, many CHW programs in LMICs were dealing with major challenges at the time. Several key studies (Walt et al. 1989; Berman, Gwatkin, and Burger 1987) highlighted the limitations of CHW programs, including inadequate training and re-training, insufficient remuneration or incentives for CHWs, limited supervision and logistical support, poor integration within formal health systems, and limited cooperation with higher level cadres of healthcare providers (Perry, Zulliger, and Rogers 2014). At the same time, governments realized that effective implementation of CHW programs would require substantial ongoing financial and supervisory support (Berman, Gwatkin, and Burger 1987).

Despite these challenges, several flagship CHW programs flourished in the 1980s – most notably, in Bangladesh, Brazil, and Nepal (Perry, Zulliger, and Rogers 2014). As a result of this success, and global recognition of persistent inequities in health service delivery, interest and investment in CHWs have re-emerged in recent decades. Since the 1990s, priorities have shifted back towards decentralization of health systems, increased coordination with community-based organizations, and task shifting of human resources for health to alleviate overextended health systems (Lehmann and Sanders 2007; Standing and Chowdhury 2008). Renewed attention to the CHW model in the nineties was also stimulated by the growing HIV/AIDS epidemic, the resurgence of other infectious diseases, and the failure of many formal health systems to provide reliable care for people living with chronic illnesses (Lewin et al. 2010).

Nowadays, a number of countries invest in large-scale CHW programs. In response to the global health priorities outlined in the MDGs, many of these programs primarily focus on training CHWs to deliver health, nutrition and family planning services to women and young children. Common intervention packages include antenatal home visits, education on safe pregnancy and childbirth, promotion of healthy maternal nutrition and child feeding practices, and diagnosis, treatment, and referral of sick infants (Haines et al. 2007). According to a recent review, the most common preventive intervention categories are malaria prevention, health education, breastfeeding promotion, essential newborn care, and psychosocial support (Gilmore and McAuliffe 2013). CHWs may be the most effective interventionists in a community, because they are uniquely positioned to deliver health education messages in a culturally sensitive way. For women with limited access to health services, CHWs may be the best source of health
education and the most reliable resource available to help them navigate multiple health care provider systems (Han et al. 2009).

CHWs for MNCH: State of the Evidence

While CHW programs are now commonplace, there is very little standardization among them and intervention designs vary widely (Liu et al. 2011). Measuring the impact of CHW activities on population health (including MNCH outcomes) is methodologically challenging, as there are myriad social, political, and economic factors that influence the health of populations (Perry, Zulliger, and Rogers 2014). Furthermore, oftentimes CHWs are only one component of complex packages of health interventions and thus it is difficult and costly to isolate the added effect of CHW activities. Finally, monitoring and evaluation protocols for national CHW programs have historically been weak and inconsistent across settings, and as such the evidence base for CHWs and MNCH remains limited (Perry, Zulliger, and Rogers 2014). In spite of this, the re-emergence of CHW-led strategies over the last two decades has resulted in additional efforts to study their effectiveness on key MNCH indicators.

It is widely acknowledged that CHWs can play a critical role in reducing infant and child morbidity and mortality in high-risk populations by encouraging positive behaviour modification among caregivers (Bhutta et al. 2005; Darmstadt et al. 2005; Haws et al. 2007; Prost et al. 2013). For example, a recent systematic review found that CHWs were especially effective in promoting maternal caregiving behaviours such as skin-to-skin newborn care and exclusive breastfeeding (Gilmore and McAuliffe 2013). In a systematic review and meta-analysis of randomized controlled trials (RCTs), women involved in CHW interventions were 5.6 times more likely to exclusively breastfeed than women who were not (Hall 2011). Another comprehensive review reported that compared to the usual standard of care, interventions delivered through CHWs were associated with significant improvements in immunization uptake and exclusive breastfeeding (Lewin et al. 2010). Similarly, an evaluation of a large-scale behaviour-change intervention in rural Mozambique found that health and nutrition messages delivered by community-based care group volunteers led to significant reductions in undernutrition among children less than 2 years of age (Davis et al. 2013).

CHWs have also been highly effective at identifying malnourished children and overseeing community-based management of severe acute malnutrition (Perry, Zulliger, and Rogers 2014).
Existing evidence suggests that using CHWs to deliver these services at the community level (as opposed to providing them at health facilities) results in similar outcomes at lower costs, and with substantially higher population coverage (Collins et al. 2006; Bachmann 2009). In addition, CHWs can help to improve micronutrient deficiencies through timely provision of appropriate micronutrients and supplements during pregnancy and early childhood (Perry, Zulliger, and Rogers 2014). A systematic review and meta-analysis by Prost and colleagues (2013) reported that exposure to participatory learning and action through women’s groups (typically facilitated by CHWs) was associated with a 23% reduction in neonatal mortality and a 37% reduction in maternal mortality. A study in Bangladesh found that home delivery of antenatal services by CHWs was effective in reducing neonatal mortality, however these authors caution that further research is needed to determine which approach works best, and in which contexts (Baqui et al. 2008).

A growing body of research also demonstrates the impact of CHW interventions on women’s health. For example, CHWs play a critical role in filling unmet needs for family planning services through community mobilization and counselling, and in some cases, direct distribution of contraceptives (Huber, Saeedi, and Samadi 2010; Stanback, Mbonye, and Bekiita 2007; Charyeva et al. 2015). Other studies report that CHWs can effectively diagnose and treat malaria (Counihan et al. 2012; Onwujekwe et al. 2006), and can contribute to the prevention of mother-to-child transmission (PMTCT) by promoting the use of antiretroviral treatment during pregnancy (Lema et al. 2014). Another important task of CHWs is providing social support during critical periods throughout the continuum of care. A randomized controlled trial in Pakistan found that women who received psychosocial support from CHWs were less likely to exhibit perinatal depression symptoms at 6 and 12 months post-delivery (Rahman et al. 2008). More recently, CHWs have been incorporated into strategies to address women’s cancers in LMICs (see Ginsburg 2013, for example). Wadler et al (2011) suggest that CHWs can make major contributions to cancer control efforts through health education, screening, and patient navigation. Other researchers have suggested that horizontal integration of community-based cancer prevention strategies into existing programs and infrastructure may be a cost-effective way to improve women’s health outcomes.

CHW programs have been employed extensively to improve women’s access to health services during pregnancy and childbirth. CHWs can facilitate improved uptake of maternal health
services in two ways: 1) they can be trained in health promotion strategies to help encourage more women to utilize facility-based antenatal care and skilled delivery services; or 2) they can be trained to deliver basic maternal health services at the village level, in the absence of clinicians. As part of a community-based reproductive health project in Tanzania, CHWs (including traditional birth attendants) were trained to provide education and referral services to mothers regarding safe motherhood. An evaluation of this project (Ahluwalia et al. 2003) found that community participation in maternal health increased as a result of project activities. Improvements in maternal knowledge of danger signs, birth planning, timely referrals, transport of pregnant women to hospitals, and support and retention of CHWs were also observed. In a similar Tanzanian study, CHWs trained to counsel women regarding safe motherhood were found to be effective in promoting both ANC attendance and skilled delivery (Mushi, Mpembeni, and Jahn 2010). The study’s pre/post test design demonstrated that the CHW intervention led to significant increases in deliveries with a skilled attendant and early ANC booking, and enhancements in male involvement in safe motherhood issues.

In settings where facility-based delivery is not preferred or unfeasible, various cadres of CHWs have been deployed to promote safer deliveries at home. For example, evidence from multiple LMICs suggests that CHWs can effectively distribute oral misoprostol tablets to women during prenatal visits or at the time of delivery (Nasreen et al. 2011; Sutherland and Bishai 2009; Rajbhandari et al. 2010). Misoprostol is a uterotonic drug that reduces the risk of postpartum hemorrhage, a leading cause of global maternal mortality (Smith et al. 2014). There is some evidence to suggest that lay health workers such as traditional birth attendants (TBAs) can be trained to conduct safe, home-based deliveries, and may lead to decreases in both maternal and newborn mortality (Jokhio, Winter, and Cheng 2005; Gill et al. 2011). This evidence base is mixed however; several other studies found that training TBAs on birthing skills and referral did not lead to decreased infant and maternal mortality rates (Gloyd et al. 2001; Smith et al. 2000). Another study reported that trained TBAs with more years of experience were more likely to use

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7 An untrained TBA is “a person – usually a woman – who assists the mother at child birth and who initially acquired her skills delivering babies by herself or working with other TBAs” and has received no formal training within the past ten years. Trained TBAs are those who have received specialized training within the past ten years, and are properly equipped with the knowledge, equipment and referral skills necessary to safely handle deliveries (WHO 1978).
potentially harmful birthing practices, which can increase the risk of postpartum morbidity following home deliveries (Fronczak et al. 2007). Based on the evidence, some experts are reluctant to divert resources to TBA training programs and question whether returns on investment are sufficient. Others believe that so long as supportive supervision and regular evaluation of trainings are in place, properly trained and equipped TBAs can make significant contributions to improving MNCH outcomes.

The evidence on cost-effectiveness of CHW programs is inconclusive. As others have noted, this is largely a result of the paucity of data and relevant published studies on the cost-effectiveness of CHW interventions in different contexts (Lewin et al. 2010; Perry, Zulliger, and Rogers 2014). A review by Vaughan and colleagues (2015) found that CHW programs can be a cost-effective approach in LMICs, but note that the evidence base is strongest for tuberculosis interventions. These authors show that CHW-based strategies to address MNCH and malaria outcomes also appear to be cost-effective, however the evidence is much weaker. Another study in Mozambique estimated that while providing CHWs with salaries would increase total program costs by 362% in 2012, this strategy would also lead to substantial efficiency gains in program implementation (Bowser et al. 2015).

**CHW Motivation and Quality of Care**

Despite a growing evidence base demonstrating positive impacts of CHW activities on MNCH, a number of substantial challenges, many of which were identified in the 1980s, still persist today. Difficulties achieving equitable service delivery and coverage, providing continual training, supportive supervision and incentives, and maintaining CHW motivation have been documented in a multitude of settings (Bhutta et al. 2010). One of the most significant challenges is preventing CHW attrition and maintaining quality service delivery, particularly among CHWs who work voluntarily. For example, a study in Bangladesh found that CHW programs tend to experience high turnover rates, as a result of time constraints, insufficient remuneration, and disapproval among CHWs’ own family members (Khan et al. 1998). A review by Haines and colleagues (2007) showed that even when CHW motivation is high, infrastructure and community location can limit the ability of CHWs to reach all clients in their target areas on a regular basis.
In contexts where CHWs augment facility-based clinical services, their interactions with women are particularly important, as CHWs tend to fill both social and clinical roles simultaneously. For this reason, it is not only crucial to consider women’s experiences with access to services; if we want to ensure they are receiving the best care possible, it is equally critical to ensure that frontline health workers are well supported within the health system. As articulated by Penn-Kekana et. al. (2007):

“Health care workers are complex human beings, motivated by a range of different financial and non-financial incentives, steeped in cultural and professional value systems. They are not robots, who blindly without thinking implement whatever they are told, nor are they angels who think of nothing but the good of their patients” (p. 30).

While the importance of financial incentives is widely acknowledged, several studies suggest that CHWs can be motivated by both intrinsic and extrinsic factors (Gopalan, Mohanty, and Das 2012; Greenspan et al. 2013; Alva, Magalona, and Sacks 2015). A recent study in Tanzania reported that a combination of both financial and non-financial incentives is critical to CHW motivation and satisfaction (Mpembeni et al. 2015). A number of recent studies have investigated the role of cognitive and motivational factors influencing CHW performance (e.g. self-efficacy, perceived barriers to, and benefits of community health work). For example, Rahman et al (2010) developed a framework to illustrate the decision making process women go through when deciding to become, or continue working as CHWs. This model includes factors such as job satisfaction, workload, perceived value of CHW work among community members, and fulfillment of pre-hire expectations. A review of motivation and retention of CHWs in developing countries (Willis-Shattuck et al. 2008) reported that CHWs are also motivated by opportunities for continuing education and refresher courses, career development and recognition by supervisors and other superiors. Given the demonstrated importance of cognitive motivation factors in CHW performance and retention, it is crucial to incorporate these concepts when evaluating interventions that aim to improve service delivery by CHWs.

CHW program gaps and unmet needs

Although CHWs have the potential to substantially improve MNCH, insufficient training and failure to adhere to clinical guidelines can also be significant barriers to program success. An evaluation of a CHW program in south-western Kenya reported that CHWs often made errors in
managing childhood illness (Rowe et al. 2007). Another study in Columbia found that without sufficient training, supervision and job aids, CHW performance can be suboptimal, leading to high error rates and low protocol compliance, even when provided with paper-based clinical guidelines (Florez-Arango et al. 2011). A general lack of systematic tools for tracking and monitoring clients prevents CHWs from following up on critical cases in a timely manner (Haines et al. 2007). This is particularly problematic during pregnancy and the postpartum period, as frequent, regular check-ups are necessary to ensure the health of mothers and their infants during these times.

Due to a lack of long-term investment in, and poor coordination of CHW programs, the reality in Tanzania and many other low-income countries is that CHWs do not have the necessary tools for effective health service provision. To realize their full potential, CHWs require appropriate data collection tools, readily available training and reference materials, improved communication channels when they encounter situations beyond their expertise, and systems for scheduling household visits and follow-up appointments with clients (Agarwal et al. 2015). In order to improve the quality of CHW care, decrease attrition rates, and ultimately improve MNCH outcomes, innovative strategies to strengthen the link between CHWs, their support network, and their intended beneficiaries are urgently needed (Shankar et al. 2008); such is the case of Tanzania. In the following section, I outline one such strategy: the use of mobile phone technology to support CHWs.

The use of mobile health technology to improve MNCH

Many scholars have documented the disparities in access to technology in LMICs compared to high-income countries, and between rich and poor individuals within countries – that is, the so-called global “digital divide” (Mechael 2009). This divide has drastically narrowed in recent years, as low-cost information and communications technologies (ICTs) proliferate throughout emerging markets worldwide. Mobile phones in particular are now readily available for relatively low costs in even the most remote regions of the global South. In fact, at least half the world’s population now has a mobile phone subscription, compared to only 20% just a decade ago (GSMA 2015), and by 2017 there are expected to be more mobile devices than people on the planet. Expansion of these devices is most striking in LMICs, which account for three quarters of internet and mobile cellular subscriptions globally (International Telecommunication...
The increasing affordability of mobile phones has led to an exponential increase in unique subscription penetration\(^8\) and mobile network coverage across sub-Saharan Africa (GSMA 2015). In Tanzania, for example, 73% of adults owned a mobile phone in 2014, versus only 10% in 2002 (Pew Research Center 2015).

The widespread availability of affordable mobile phones presents an unprecedented opportunity to leverage mobile technologies for health education and service delivery. Accordingly, we have witnessed the recent emergence of electronic health (“eHealth”), which is broadly defined by the WHO as the “use of information and communication technology for health” (WHO 2011). Mobile health (or “mHealth”), a subcategory of eHealth, is a rapidly evolving field that offers some promising tools to address health system weaknesses, including gaps in CHW programs. The World Health Organization defines mHealth as “medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants, and other wireless devices” (WHO 2011). Broadly, mHealth refers to the use of mobile technologies to improve the delivery of, and access to, health services and information (Labrique, Vasudevan, Chang, et al. 2013). Mobile health innovations can take various forms. For example, applications have been developed to support data collection and management, health promotion campaigns, emergency medical response, point-of-care diagnostics and clinical decision-making (Labrique, Vasudevan, Kochi, et al. 2013). Various delivery modes, including short-message-service (SMS), voice calls, and audiovisual-equipped smartphone applications have been employed in many settings.

According to a recent review, the most commonly documented use of mHealth in LMICs is sending unidirectional text and phone reminders to patients/clients (often referred to as “end users”) to promote follow-up appointments and healthy behaviors (Kallander et al. 2013). For example, the Mobile for Reproductive Health (m4RH) program delivers family planning messages via SMS to male and female users in Kenya and Tanzania. This has been cited as a cost-effective way to improve young people’s access to family planning education (L’Engle et al. 2013). Another notable example of this is the Mobile Alliance for Maternal Action (MAMA)

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\(^8\) A “unique mobile subscriber” is a single individual that has subscribed to a mobile service. This individual could hold multiple mobile connections (i.e. SIM cards) (GSMA 2015).
program, which delivers “age and stage-based messages [SMS or interactive voice recordings] aligned with global best practices” to new and expectant mothers (Mobile Alliance for Maternal Action 2015b). MAMA is currently one of the largest mHealth initiatives in LMICs; the organization provides direct support to programs in Bangladesh, South Africa, India and Nigeria, and its message content has been adopted by organizations in a number of other LMICs. Preliminary studies of the MAMA program found positive results in terms of user satisfaction, however available findings are not based on rigorous study designs. As MAMA management has pointed out themselves, “while structured and systematic, survey methods used lacked significant sample sizes as well as scientific comparators (i.e., a baseline or a control group) at the outcome level” (Mobile Alliance for Maternal Action). Consequently, they have called for prioritization of more rigorous program effectiveness and implementation studies to inform scale-up activities.

A similar national, safe-motherhood campaign known as Wazazi Nipendeni (Love me, parents!) was launched in Tanzania in 2012. This campaign delivers messages through a number of channels (e.g. radio, TV, brochures) including user-subscribed SMS messaging. Using data from over 1,700 exit interviews at health facilities in 5 regions, evaluators found that message exposure (through any modality) was a significant predictor of knowledge of danger signs, birth planning, and a marginally significant predictor of health facility delivery (Kaufman 2014). Furthermore, for each message source to which a woman was exposed, she was 20% more likely to deliver in a health facility, even after controlling for potential confounding variables. It is not clear whether the SMS component of the intervention had an additive impact, as stratified analyses are not published, however a majority of women (83%) reported exposure to messages via radio, versus 9% reported exposure via SMS messaging, suggesting that SMS may have played a relatively minor role in influencing the reported outcomes.

In Zanzibar, Tanzania, researchers conducted a cluster-randomized controlled trial of a similar intervention that equipped “wired mothers” with vouchers for direct two-way voice communication with healthcare providers, and sent regular automated SMS messages to promote antenatal and postnatal care attendance, as well as skilled delivery (Lund et al. 2012). The intervention, which included 2500 women across 24 health facilities, led to significant improvements in antenatal care attendance, skilled delivery (particularly in rural areas) and perinatal mortality (Lund, Rasch, et al. 2014; Lund et al. 2012; Lund, Nielsen, et al. 2014).
Another trial in Kenya reported improved antiretroviral treatment adherence among patients receiving weekly SMS support from a healthcare provider (Lester et al. 2010). These two key trials were among the first published mHealth studies from developing country settings that a) adopted a randomized design; and b) measured the impact of SMS support on patient-level behaviour change outcomes. The Wired Mothers study was the first to rigorously evaluate the impact of SMS on MNCH outcomes, specifically.

As Lee and colleagues (2016) illustrate in their recent review, the effectiveness evidence on mHealth interventions for MNCH in LMICs remains mixed. However, several recent studies have investigated the impact of direct voice communication and SMS messaging on MNCH and nutrition outcomes, and show promising results. A case-control study in Nigeria found that providing pregnant women with free mobile phones (to be used for direct communication with health workers) and improving the overall quality of facility-based services resulted in significantly higher facility utilization rates by pregnant women (Oyeyemi and Wynn 2014). In a Kenyan trial, Sellen and colleagues (2014) compared three models of breastfeeding support: mobile phone–based peer support; monthly in-person peer support groups; and current standard facility-based support. This study found that mobile phone-based counselling was at least as effective in supporting exclusive breastfeeding as peer support group and facility-based strategies (Sellen et al. 2014). A cluster-randomized controlled trial in Nigeria reported improved exclusive breastfeeding to 6 months among women participating in a prenatal text and voice-based breastfeeding promotion and microcredit program (Flax et al. 2014). In quasi-experimental study in Shanghai, China, women in the intervention group received weekly SMS messages about infant feeding beginning in the third trimester (Jiang et al. 2014). Compared to the control group, women in the intervention group had a significantly longer median duration of exclusive breastfeeding at 6 months, and a lower rate of introduction of solid foods prior to 4 months. In a meta-analysis of the three aforementioned trials, pooled estimates show that early initiation of breastfeeding (within one hour after birth) and exclusive breastfeeding in the first 3-6 months were higher among women who received a prenatal SMS or mobile phone intervention compared to women in control (routine care) groups (Lee et al. 2016).

In addition to SMS-based health promotion strategies, other mHealth interventions that specifically target MNCH have aimed to facilitate emergency medical response, data collection, and point-of-care support during pregnancy and delivery (Tamrat and Kachnowski 2012). Many
of these strategies depend on the work of frontline health workers, including CHWs. Interventions combining both CHWs and ICT solutions have the potential to synergistically improve MNCH by a) allowing CHWs to connect to more clients, with improved efficiency; and b) providing them with the necessary tools to enhance the quality of services provided (Agarwal et al. 2015; Tamrat and Kachnowski 2012). Mobile phones can be used as job aids by CHWs and serve a number of specific functions (see Figure 1). For example, they can be used to improve health information tracking and facilitate communication between CHWs, their supervisors, and their clients. Case studies in Egypt and Malaysia demonstrated that mobile communication between CHWs and more highly skilled healthcare workers improved point of care decision-making by CHWs, as well as health outcomes among their clients (Mechael et al. 2010). Direct communication via voice calls and SMS messaging can also enable supervisory support, a critical component of any effective CHW program. Hill et al. rightfully note however, that while using mHealth to improve supervision is a promising strategy, this approach has not been rigorously tested, and warrants further research (Hill et al. 2014).

Figure 2. Possible Applications of mobile health technology for CHWs
Mobile applications have also been designed to link CHWs to electronic medical records, enabling improved data collection and patient tracking (The Earth Institute CHW Technical Taskforce 2011). The Millennium Villages Project’s “ChildCount+” program in Kenya is a demonstrative example. In just a few months, a mobile tracking application allowed CHWs to register and routinely monitor 95% of children under five in a population of over 55,000 people (The Earth Institute CHW Technical Taskforce 2011). Improved supervision and monitoring may enhance the quality of data collected by frontline health workers. Another study in South Africa found that a mobile data collection tool could be used feasibly by CHWs to conduct household surveys with minimal data loss (Tomlinson et al. 2009). In this project, a complementary web-based interface for supervisors permitted daily real-time supervision of CHW performance, enabling supervisors to identify cases of data fabrication. While these results are encouraging, authors note that the study design did not include a control group, and thus a “randomized basis for comparison” could not be achieved.

Among the most common mHealth modalities for frontline health workers are point of care decision-making applications, often operated on basic smartphones. Rather than linking CHWs to higher cadre clinicians in real time, they provide electronic support by guiding CHWs through a series of diagnostic questions during client interactions. Based on a client’s responses, the health worker is prompted to deliver counselling on specific topics, or in some cases, to make a diagnosis, and recommend a treatment or course of action (e.g. referral to a higher level of care) (Kallander et al. 2013). Some applications are linked directly to Ministry of Health systems. In Ghana for example, the Mobile Technology for Community Health (MoTeCH) application links data collected by CHWs during patient consultations to Ghana Health Service-recommended treatments (The Earth Institute CHW Technical Taskforce 2011). Other applications include audiovisual components (video/voice recordings), which can augment counselling and education delivery.

The most widely used point-of-care application is CommCare, an open source cloud-based tool with built-in client tracking, decision support and multimedia functionalities. This application was developed in 2007 and has been used in more than 40 countries to replace the “cumbersome paper registers, reporting forms, and client education flipcharts” typically used by frontline health workers (Chatfield et al. 2015). One of the major benefits of point-of-care mobile applications is that CHWs do not need to regularly rely on support from higher cadre clinicians,
who tend to be overburdened with their own clinical responsibilities at primary healthcare facilities. While the technology is not intended to replace the expertise of highly trained health professionals, it may streamline and strengthen existing diagnostic and referral systems.

The published evidence base for point-of-care applications is limited but growing. Many studies on CommCare for example, present implementation narratives, describing “the process and lessons learned from system implementation, with little or no rigorous evaluation” (Chatfield et al. 2015). A recent review found that published studies report on the feasibility or effectiveness of these tools, but few have measured impact on specific health outcomes (Agarwal et al. 2015). For example, a South African study showed that an electronic application could be used by CHWs to correctly triage most HIV-positive patients on antiretroviral medication (Mitchell et al. 2008). Another South African study reported a five-fold increase in adverse event submission rates among CHWs using a CommCare-based application to manage and track Tuberculosis patients (Chaiyachati et al. 2013). In Tanzania, CHWs were trained to deliver an electronic protocol for integrated management of childhood illness (IMCI). Researchers found that protocol adherence by CHWs using electronic IMCI was greater than those who used standard paper-based IMCI protocols (Mitchell et al. 2013).

Much of the existing research on mHealth for frontline health workers has explored the perceptions and experiences of technology users themselves. Since CHW performance is known to have substantive impacts on MNCH outcomes (Bhutta et al. 2010; Haines et al. 2007), this is considered a crucial step in evaluating mHealth programs. Some authors suggest that equipping CHWs with ICTs may also help to motivate them to continue working (Brunie et al. 2014; Strachan et al. 2012). Formative research with CHWs in Uganda and Mozambique found that the most important applications of mHealth were those that could reduce the need for travel, improve efficiency and planning, transfer feedback and information, and improve communication with supervisors and colleagues (Thondoo et al. 2015). CHWs in this study also claimed that their motivation and performance could be enhanced with mHealth applications that increased their visibility and credibility, and delivered SMS messages of encouragement to celebrate achievements and acknowledge the importance of their work. A qualitative inquiry into the experiences of CHWs in India reported that use of CommCare boosted their credibility and improved perceived authority of information sources among clients (Schwartz et al. 2013).
Research gaps and opportunities in mHealth

While many studies have investigated the feasibility and acceptability of mHealth tools among CHWs, comparatively less research has honed in on the perspectives of their clients. A study in Tanzania that did include client perspectives found that parents of sick children who were counselled with a precursor to CommCare\(^9\) reported positive views of the tool, stating that health workers conducted more thorough examinations and had more knowledge about child illnesses compared to CHWs using standard protocols (Mitchell et al. 2012). Lewin et al (2010) caution that while uptake of certain interventions may aid CHWs with their work, they may not necessarily lead to effective delivery of health services to clients. This is problematic because we know that when patients are dissatisfied with the quality of health care received, they are less likely to continue utilizing services (Haddad, Fournier, and Potvin 1998). If the aim is to use ICTs to help modify health-related behaviours, then it is critical to ensure that both health workers (end users) and their clients (intended beneficiaries) are receptive to, and satisfied with smartphone-supported services.

It has been proposed that the use of mobile phone applications may enhance community-based MNCH services by a) contributing to CHW motivation; b) improving patient identification, tracking, and management; c) refining point of care decision making and diagnostics; and d) enhancing quality of care through interactive, electronic education modules that can improve the client experience. Recent reviews of mHealth strategies in LMICs (Tamrat and Kachnowski 2012; Agarwal et al. 2015; Lee et al. 2016) arrive at the same overall conclusion: that while mHealth strategies for frontline health workers (including CHWs) offer promising approaches to improving health care delivery; evidence for the effectiveness of such strategies on health outcomes remains insufficient. Lee and colleagues (2016) found that most studies of mHealth for MNCH in LMIC are of poor methodological quality, and few have measured impacts on health outcomes. While the evidence for patient knowledge and behaviour outcomes is growing, many studies have not been rigorous – there are few trials with randomized designs. Further, interpretation and replication is difficult due to “ambiguous descriptions of interventions and their mechanisms of impact” (Lee et al. 2016, p. 1).

\(^9\) “eIMCI” – an electronic protocol for Integrated Management of Childhood Illness
With respect to mHealth and behaviour change, there is much theoretical work to be done. Donner and Mechael rightfully point out that “we cannot skip from use of technology to measuring health outcomes, without understanding the mechanism of change by which we expect the health outcomes to improve” (Donner and Mechael 2012, p. 7). This observation is echoed by Maar and colleagues, who note that with respect to SMS messaging for behaviour change, the message development process in particular is a component that is commonly hidden within a black box, lacking deconstruction of the steps involved in creating messages as well as rigorous evaluations of the quality of the health communication messages” (Maar et al. 2016, p. 6). The same is true for job aids like CommCare, which ultimately aim to change health behaviours.

Based on lessons learned from a systematic review of SMS tools for behaviour change (Cole-Lewis and Kershaw 2010), Cole-Lewis (in Donner and Mechael 2012, p. 6-39) outlines seven key limitations of the existing evidence:

- poor measurement due to a lack of conceptual models for behaviour change
- lack of scientific rigor
- lack of long-term follow-up
- little representation of developing countries in the scientific evidence
- inadequate intervention descriptions
- lack of behavioural theory use
- access to information (i.e. publishing studies in journals that are not open access)

Most of these limitations still hold true and apply to mHealth studies in general, however, the situation is beginning to improve. Very recently, the WHO mHealth Technical Evidence Review Group published a comprehensive checklist – “mERA”10 which outlines specific reporting criteria for mHealth studies on content, context, and technical features (Agarwal et al. 2016). These authors suggest that with widespread adoption of the mERA checklist, the quality of mHealth evidence reporting will improve and replication of useful interventions may be possible. Questions regarding scalability and sustainability of mHealth interventions remain, as

10 “mERA” - mHealth evidence reporting and assessment checklist
the most recent review (Lee et al. 2016) did not find any study evaluating the cost-effectiveness of mHealth approaches.

Researchers might ask themselves, what are the mechanisms between CHWs’ use of electronic job aids and maternal health seeking and caregiving? Is it simply that the CHW becomes more proficient with their work and the messaging is improved? Or is there something about the client’s interaction with or interpretation of the technology itself that might lead to behaviour change? How exactly does ICT-based counselling influence women’s decision making? For job aid applications in particular, two levels of behaviour change must be considered: 1) the actual user of the ICT; and 2) the intended beneficiary (women clients in many cases). Gaps in the existing literature underscore the importance of addressing these considerations from both theoretical and practical perspectives. These key underlying questions form the basis of this thesis.
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Chapter 3
Methods

Programmatic context and study setting

This study was conducted from September 2013 to July 2014 within the context of a larger project, *Supporting Systems to Improve Nutrition, Maternal, Newborn, and Child Health* (SUSTAIN-MNCH; hereafter referred to as ‘SUSTAIN’). The three-year SUSTAIN project emerged as part of Canada’s Muskoka Initiative Partnership Program. It was led by World Vision Canada (WVC), and implemented by World Vision Tanzania (WVT) in Singida Rural and Iramba, two districts in Tanzania’s central Singida Region (Figure 3). The overall aim of SUSTAIN was to improve MNCH and nutrition outcomes by strengthening the existing health care system through improved access to affordable, sustainable community-based services. The project was aligned with Tanzania’s national MNCH strategic plan (United Republic of Tanzania Ministry of Health and Social Welfare 2008) and aimed to strengthen the capacity of the two districts to deliver MNCH services, enhance household nutrition practices and increase demand and utilization of services (World Vision Canada 2013).

Figure 3: Singida Region, highlighted in red (left); and SUSTAIN project areas: Iramba and Singida Rural (right).11

11 Image source: Google Maps (https://www.google.ca/maps)
Singida region was selected as the target area for the SUSTAN project due to its disproportionately high poverty rates, poor MNCH and nutrition indicators, and relatively weak health infrastructure. As one of Tanzania’s poorest regions, Singida is home to 1.4 million people, 57% of whom fall within the lowest two national wealth quintiles (National Bureau of Statistics [Tanzania] and ICF Macro 2011). Singida region has only 158 health facilities, the second lowest in the country after Manyara region. While almost all women in Singida access antenatal care at least once during pregnancy, less than half deliver with the assistance of a skilled provider (National Bureau of Statistics [Tanzania] and ICF Macro 2011) and the maternal mortality rate was 468 deaths per 100,000 live births in 2012 (Tanzania National Bureau of Statistics and Ministry of Finance 2015).

Singida Rural and Iramba are two of the largest districts in Singida Region (20,064 km²) with a total population of approximately 936,000 people occupying 20,064 km² of mainly semi-arid land (World Vision Canada 2013). In the communities under study, the populations of men and women were relatively equal. For example, in WVT’s program area in Iramba district, 50.4% and 49.6% of residents are men and women, respectively (Mtega 2015). According to a baseline report by World Vision, facility-based delivery rates in Singida were lower than in Iramba prior to SUSTAIN project implementation (54% and 63%, respectively) (World Vision Canada 2012). A majority of households in these districts belong to one of two ethnic groups: Nyiramba and Nyaturu, and most families rely on crop and livestock production as their primary livelihood source.

**Tanzania Integrated Maternal, Newborn and Child Health Program**

In 2012, the Tanzania Ministry of Health & Social Welfare approved an integrated Maternal Newborn and Child Health (iMNCH) training program for CHWs, in an effort to standardize CHW duties and expectations across the country, and accelerate progress towards Millennium Development Goals 4 and 5. This three-week curriculum trains community-elected CHWs to make regular household visits to mothers and children at specific times throughout pregnancy, infancy and early childhood to provide education and counselling on birth preparedness, infant feeding and nutrition, the importance of attending antenatal clinics, and safe delivery, among other topics. CHWs learn to identify danger signs during pregnancy and following delivery, and to refer clients to health facilities accordingly. To promote healthy behaviours, CHWs are
provided with paper-based register books, and photo flipcharts (bango kititas in Kiswahili), which are used as counselling tools during household visits. Prior to implementing the smartphone intervention, all CHWs in SUSTAIN project areas were trained on the iMNCH program.

The SUSTAIN smartphone application (SP+) for CHWs

Over the first 6 months of the SUSTAIN project in 2012, WVC and WVT held a number of consultations with key mHealth stakeholders in Tanzania, including MoHSW, Ifakara Health Institute, Medicos del Mundo\(^\text{15}\), D-Tree International\(^\text{16}\) and Jhpiego\(^\text{17}\). These meetings helped both SUSTAIN staff and the research team to understand the country’s mHealth landscape and key research and implementation priorities moving forward. At that time the MoHSW did not have a national mHealth strategy in place, but they had appointed a key point person at the Ministry (Dr. Mwendwa Mwenesi), who now leads Tanzania’s national mHealth community of practice (COP). This group continues to hold quarterly meetings in Dar es Salaam to facilitate coordination and knowledge sharing among over 90 partners working on mHealth projects across the country (World Vision Canada 2013). D-Tree is an active member and key stakeholder in this group. At the onset of SUSTAIN, D-Tree had already begun collaborating with Jhpiego on a project to develop a smartphone-based application for CHWs working in Tanzania’s Morogoro region.

Given D-Tree’s close relationship with MOHSW and their experience on similar projects with Jhpiego, WV partnered with D-Tree to develop an antenatal and postnatal smartphone (SP) application for use by SUSTAIN project CHWs during household visits. The application was developed using CommCare software, an open source platform designed specifically for use by CHWs. CommCare has been used as a template to develop CHW-focused tools in various contexts around the world, and can be adapted to suit particular contexts and user profiles (Dimagi Inc. 2016). The application was developed in alignment with national iMNCH program

\(^{15}\) Medicos del Mundo (“Doctors of the World”) is a non-profit organization based in Spain

\(^{16}\) D-tree International is a non-profit organization dedicated to developing medical algorithms that enable health workers to provide a high standard of care in hard-to-reach areas (http://www.d-tree.org/).

\(^{17}\) Johns Hopkins Program for International Education in Gynecology and Obstetrics
guidelines and was intended for use along with the ministry-developed photo book tool during counselling sessions with clients (combined intervention hereafter referred to as SP+). The MoHSW Reproductive Health Division approved all electronic protocols prior to implementation. While I was present for many of the planning and application refinement meetings with the D-Tree and the MoHSW, my main role was to understand the development process rather than lead application development. Most importantly, I provided scientific inputs on how the implementation of SP+ could be done to facilitate a systematic impact evaluation. I did provide some technical inputs related to MNCH and behaviour change theory as needed, the development of the application itself was done mainly by WVT and D-Tree.

Basic functions of the application include client registration and data management; home visit scheduling; time-tailed counselling prompts; referral and follow-up; and data management and reporting. The SP application is used by CHWs to register pregnant women as soon as they are identified at the village level. Once registered, the tool prompts CHWs to monitor the status of clients throughout pregnancy and following delivery. During prenatal and postnatal household visits, the application guides CHWs through electronic “decision tree” protocols, directing them to specific health/nutrition counselling topics and messages based on the woman’s gestational age, and her answers to various diagnostic questions. The tool directs CHWs to particular lessons in the iMNCH photo book, and reminds them to explain the importance of seeking antenatal care and to encourage skilled birth assistance at health facilities, for example. The application also helps CHWs to identifying danger signs during pregnancy and the postpartum period, flags clients who require immediate referral to health facilities, and reminds CHWs to follow-up with clients who were previously referred to clinics.

World Vision & University of Toronto Collaboration

The data supporting this thesis derives from a research collaboration between the University of Toronto (UofT) and World Vision. The UofT research team, which I led under the supervision of Professor Sellen (project PI), partnered with WVC when the SUSTAIN project began in January 2012. UofT conducted operational research on mHealth for frontline CHWs in SUSTAIN project areas, including a cluster-randomized evaluation of a smartphone intervention (SP+) tailored to support the work of SUSTAIN project CHWs in promoting and supporting
uptake of maternal health services. UofT research activities and deliverables to WVC included the following:

- Participated in a project inception mission to Tanzania in February 2012, contributing to initial joint planning and annual work plan development with WVC, WVT, and other stakeholders;
- Contributed to landscape analysis of current mHealth initiatives and activities in Tanzania, to aid in the selection of an appropriate mHealth application and partner;
- Developed the research methodology and study protocol;
- Obtained necessary approvals for the research protocol from research ethics boards in Canada (UofT Health Sciences IRB) and in Tanzania (NIMR and COSTECH);
- Provided some technical (MNCH-related) and theoretical (behaviour change-related) inputs into the development of the smartphone application for CHWs, in consultation with WVT, the Tanzanian Ministry of Health & Social Welfare (MoHSW), and other partners;
- Observed all mHealth project implementation activities, including training of CHWs in both study arms;
- Organized, managed, and executed data collection and analysis, both directly and through recruitment, training and supervision of local research assistants;
- Managed the research budget, and prepared regular narrative and financial reports for SUSTAIN project manager at WVC;
- Disseminated research findings through written reports and publications, and with project stakeholders through various forums in Tanzania and Canada.

Use of Mixed Methods Research

Mixed methods research is “a research design (or methodology) in which the researcher collects, analyzes, and mixes (integrates or connects) both quantitative and qualitative data in a single study or a multiphase program of inquiry” (Creswell and Plano Clark 2011, p. 119). The use of mixed methods in health systems research has become increasingly common in recent decades because it enables researchers to gain nuanced understandings of the complex social, economic and cultural contexts that shape health systems performance (Ozawa and Pongpirul 2014).
Furthermore, mixed methods are particularly useful for analyzing problems from multiple perspectives, and can therefore increase the rigor of study designs. Using mixed methods allows researchers to compare, verify or triangulate results, contextualize information, and illustrate more complete, macro-level depictions of health systems (Klassen et al. 2012). As Borkan (2004) points out, this approach not only expands the research tools available to investigators; it also enables incorporation of additional viewpoints and insights that are beyond the scope of any single technique alone.

The complementarity afforded by mixed methods can extend “the comprehensiveness of evaluation findings through results from different methods that broaden and deepen the understanding reached” (Bamberger 2012). Studies combining statistical analyses with information about local realities and personal experiences can be highly informative, since the latter can be used to interpret the former by explaining the ‘whys’ and ‘hows’ underlying statistical findings (Spangler and Bloom 2010). Despite the recent popularity of mixed methods research, very few published studies on maternal health services utilization have employed these approaches. Similarly, with respect to mHealth, there is a dearth of well-designed mixed methods studies exploring the multiple dimensions of program development, implementation, and impact.

Given the multifaceted nature of my research questions, and the goal of understanding the context, implementation process, and impact of SUSTAIN’s SP intervention, this study necessitated the use of mixed methods. As other researchers have noted, mixed methods are best suited for evaluating mHealth interventions because they allow us to study the “typical quantitative questions such as the change in health outcomes”, while also “digging deep to understand the complexities of intervention components” (Cole-Lewis 2013, p. 33). With this in mind, I aimed to investigate multiple aspects of the intervention to gain the most comprehensive understanding of the situation as possible. While it was clear that some research questions would be best answered through quantitative methods (e.g. what is the impact of SP+ on the likelihood of facility-based delivery?), I reasoned that others would be most thoroughly addressed through qualitative methods, or a combination of the two. For example, to investigate whether SP use influences CHWs’ perceived self-efficacy and job satisfaction, quantitative metrics captured via surveys would be most appropriate. However, in-depth qualitative interviews would be more useful for understanding how CHW experiences shape these
constructs. Similarly, while quantitative methods were most suitable for investigating which maternal predictors (i.e. age, parity, socioeconomic status) are associated with women’s health-seeking behaviours, this method alone only confirms or rejects hypotheses that were thought to be important at the onset of the study. In other words, quantitative survey instruments would be useful to test specific pre-determined hypotheses, but qualitative research would illuminate new possibilities not previously considered.

Spangler and Bloom’s (2010) study of biomedical obstetric care utilization in rural Tanzania was a source of invaluable insight, particularly during the evaluation design phase. Their study assigned equal weight to quantitative and qualitative components, demonstrating how mixed methods can be used concurrently to triangulate a phenomenon of interest. By applying this approach, their research led to important insights into the various factors that impact women’s decision-making regarding delivery location. For example, quantitative analyses demonstrated that parity, education, ethnicity and household assets were strongly associated with women’s birthing decisions. In addition, qualitative findings revealed that obstetric care utilization was also influenced by less tangible factors such as women’s self-identity and decision-making power, constructs which would be difficult to operationalize, standardize, and quantify. Qualitative inquiry can provide suggestions as to why the measured associations exist, which may result in more meaningful recommendations, tailored to specific contexts (Spangler and Bloom 2010). As the authors argue, strategies to improve maternal healthcare are ineffective when they are “based on inadequate knowledge of women’s lives, or assume universal ideals regarding women’s desires and capabilities” (p.767). Spangler and Bloom promote the use of mixed methods research to strengthen the evidence for maternal healthcare utilization patterns, and argue that this is essential if well-informed program and policy decisions are to be made.

Positionality and Reflexivity

As indicated above, I was closely involved in WV’s mHealth project from project inception through SUSTAIN closeout in April 2015. This meant that despite my role as an external, arms-length researcher, I did have the opportunity to provide scientific inputs during the application refinement, training, and implementation stages. Considering my position as a doctoral researcher, I privileged and upheld my role as external researcher to avoid conflict and confusion regarding my role in the SUSTAIN project. At the same time, close involvement
throughout the life of the project was crucial to my understanding of the context and “on the ground” realities, and implementation challenges. I also came to know SUSTAIN project CHWs quite well, which I believe led to increased trust, understanding and openness between participants and myself. Participating in regular meetings and casual, ‘off the record’ conversations with CHW participants over the course of the project garnered just as much meaningful information and learning as formal interviews.

While having this level of involvement enhanced the study in many ways, it is important to think critically about my positionality in relation to that of the study participants, and my dual role as a doctoral student and lead researcher in the SP+ evaluation. The concept of positionality is based on the premise that “gender, race, class, and other aspects of our identities are markers of relational positions rather than essential qualities” (Maher and Tetreault 1993, p. 118). Some aspects of the researcher’s identity (e.g. age, ethnicity, gender, socioeconomic status) are fixed, and visible, and thus careful consideration of how one’s positionality influences relationships with research participants is essential, particularly in qualitative research, which is predicated on interactions between researchers and participants. Since the nature and quality of qualitative data is tightly linked to these relationships, consideration of these differences is critical to ensuring the accuracy and reliability of qualitative research findings (Walker, Read, and Priest 2013).

Coupled with positionality is the concept of research reflexivity – that is, the process of acknowledging and continuously critiquing throughout the research process how one’s prior knowledge, experiences, values and belief systems might influence the conduct and outcome of research studies (Kvale 2006; England 1994). As noted by Bourgeault et al. (2010), “it is an inescapable existential fact that we are part of the world we study and our ‘findings’ are inevitability a product of our location and relationships in the field” (p. 357). England (1994) reminds us that research constitutes a shared space that is occupied and shaped by both researchers and study participants. Consequently, the identities of both parties have an impact on the research process. Practicing reflexivity also helps researchers to minimize confirmation bias, or the tendency to seek out and report data that supports their own ideas about the key findings of a study (Walker, Read, and Priest 2013). Reflexivity is a particularly important practice in qualitative research, as it addresses the socially embedded dynamics of data gathering. It requires researchers to recognize the asymmetrical power dynamics that exist
between themselves and study participants, and to be transparent about this in their analysis and presentation of results (Kvale 2006).

When deciding who would be responsible for collecting qualitative data on the subjective experiences of CHWs and their clients, it was particularly important to consider the ways in which my presence as an educated, Caucasian, North American female might impact participant responses. Would CHWs feel they were being evaluated or judged in some way? Would pregnant women be reluctant to discuss their experiences openly and honestly? Would participants feel pressured to give the “correct” response to appease the foreign public health researcher? In the end, the research team decided that training a team of Tanzanian researchers to collect data in Swahili (as opposed to conducting interviews myself, with the assistance of an interpreter) was the most appropriate approach. I reasoned that this approach would minimize undue influence on study participants while at the same time ensuring the highest possible quality of data. During observations, follow-up discussions and informal meetings with study participants, I made every effort to foster what Smith (1998) described as reciprocal relationships by approaching these interactions with humility and an openness to learning from participant experiences without passing judgement.

With respect to the quantitative portion of the study design, the reflexive process was centred on my pre-existing knowledge of, and assumptions about the potential benefits of mHealth interventions. Reflecting on the early days of my PhD, prior to the bulk of my fieldwork and in-country experience, I was inherently hopeful and optimistic about the potential impact of mHealth and other innovative health interventions. It was, and is still, an exciting time to work on eHealth/mHealth research, as we are constantly hearing about the potential value added by so-called “disruptive technologies” (Yellowlees et al. 2011). I was excited for the opportunity to test and potentially, to deliver solid scientific evidence in favour of these claims. As Cole-Lewis has also described, I realized that during the early stages I was “rooting for mHealth” – and as such, was subconsciously hoping the study would lead to favourable results (Cole-Lewis 2013).

My biases shifted back and forth throughout the course of my studies. Despite my initial optimistic perspective, and as I learned more about the complexities of women’s health seeking behaviours and the daunting health system challenges that persist in impoverished settings, I developed a healthy level of skepticism about mHealth and wondered how this very specific
intervention could possibly lead to changes in health behaviour, especially in such a relatively short period of time. I found myself grappling with mHealth’s “hype or hope” dilemma (Labrique et al. 2013), questioning whether such innovations could really contribute to meaningful long-term change. Given my fluctuating stance on mHealth, and the inherent biases I brought to various stages of the research, it was critical to develop a scientifically rigorous study design, and to take steps that would minimize risk of jeopardizing the scientific process. I realized early on that in order to do a good job as an arms-length evaluator and researcher, I needed to make a conscious effort to maintain impartiality from start to finish.

Because I spent an extended period of time living and working in Tanzania, I came to know both field staff and some of the CHWs personally. Consequently, it was sometimes difficult to uphold my neutral position as the external, ‘non-biased’ researcher. This experience was invaluable as it allowed me to gain a nuanced perspective of how programs are implemented within the context of everyday life in rural Tanzania. However, I was acutely aware that both real and perceived professional and personal relationships could influence study participants’ perceptions of me and of the research. While the research team attempted to maintain a neutral stance (by asking non-leading questions during interviews, for example), it was clear that many CHWs saw the study as an opportunity to voice their concerns, and many hoped the research would serve as a platform to bring about positive changes in their working conditions and in their communities. It was sometimes difficult to manage these expectations, as I could not guarantee that communicating participants’ views and experiences would translate into desired programmatic and political responses.

At the same time, I came to know World Vision staff in both Canada and Tanzania quite well – these individuals became both colleagues and friends, which is in my opinion a major benefit of working collaboratively in global health. At some points I worried that if the study produced negative or less favourable results, this may reflect poorly on World Vision and other organizations involved in the SUSTAIN project. It was during these periods that I had to take a step back, and recalibrate my position as an external evaluator. While the aim was to approach this project as an ‘outsider’ and maintain a non-biased perspective throughout the process, it would be disingenuous to claim that this was a simple task.
Ethical Considerations

The Office of Research Ethics at the University of Toronto, Canada, the Tanzanian National Institute for Medical Research (NIMR) and the Tanzanian Commission for Science and Technology (COSTECH) approved the research protocol, and COSTECH issued a 1-year research permit, allowing me to conduct primary data collection in Singida Region. Approved informed consent scripts and forms are included in Appendix A. The study adhered to standard ethical guidelines and best practices with respect to informed consent, confidentiality, and participant anonymity. All research team members (including data collectors) completed the National Institutes of Health online training course, Introduction to the Responsible Conduct of Research, and signed a confidentiality agreement.

Upon consultation with the director of the office of research ethics (University of Toronto Health Sciences REB), it was determined that this study did not need to be registered as a trial. As research partners, the UofT team provided key scientific inputs to WV during the implementation phase, however our research team did not develop the intervention content independently, and further, we did not lead or provide any training on the SP+ intervention. Since WV did this independently of our team, we were not responsible for delivering the program. We were responsible for the evaluation of a randomized intervention only, and thus we were not required to register the study as a trial.

Hypothesized pathways to impact

In theory, CHWs’ use of SP+ during client visits should lead to enhanced quality and accuracy of time-sensitive health advice and counselling, fewer reporting errors, improved accuracy of data collected, and more timely referral and follow-up. These factors combined were expected to strengthen links between communities and health facilities. It was thus hypothesized that smartphone-assisted counselling would lead to improved maternal health-seeking behaviours (e.g. higher health facility delivery rates), care practices (e.g. early initiation of breastfeeding and exclusive breastfeeding for 6 months) and better knowledge of MNCH topics covered during counselling sessions (e.g. awareness of danger signs and optimal infant feeding/caregiving behaviours).
A logic model exploring potential pathways to impact was derived after an initial literature review and site visit to Singida (Figure 4 below). I referred to this model frequently during the design, analysis and interpretation stages of the study. The model outlines theorized pathways and mechanisms between the SP+ intervention and desired health outcomes, mainly how exposure to counselling by SP-supported CHWs could lead to improved decision making support and quality of counselling, increased frequency of visits and clinical referrals, improved communication and improved privacy and confidentiality. Theoretically, if these changes are experienced (or even perceived) by clients, then we might expect to see positive health behaviour changes and thus more favourable health outcomes as a result. The proposed pathways to impact, of course, depend on a number of contextual factors at multiple levels: 1) individual CHW factors (e.g. job satisfaction, self-efficacy); 2) health system factors (e.g. distribution and quality of health facilities); and 3) individual maternal factors (e.g. age, education, reproductive history, etc.). A majority of these factors are pre-existing, “fixed” factors and therefore must be measured and controlled for during analysis. However, I hypothesized that several factors in the model – CHW job satisfaction and self-efficacy for fulfilling job expectations, as well as perceived quality of care among women – may differ between intervention and control groups, and thus would have to be explored as potential modifying factors if an impact was measured.
Research Objective and Aims

The overall objective of this study was to investigate whether the smartphone tool could be used by CHWs to increase women’s uptake of maternal health services in Singida region, central Tanzania. Specific research questions were as follows:

1. What is the impact of SP+ on women’s utilization of facility-based delivery (primary outcome)?
2. What is the impact of SP+ on women’s awareness of healthy nutrition practices during pregnancy and delivery, awareness of danger signs during pregnancy, early breastfeeding practices, and postnatal care uptake (secondary outcomes)?

In addition to measuring specific impacts of the SP intervention, I also aimed to answer the following process-related questions:

3. a. How does SP+ influence CHWs’ motivation and work experience?
   b. Do job satisfaction and perceived self-efficacy for fulfilling job expectations differ among CHWs depending on SP+ use?

Figure 4: SP+ Intervention Logic Model of Hypothesized Pathways to Impact
4. How does SP+ influence perceived quality of care among CHW supervisors and female clients?
5. What are the barriers and facilitators of maternal health services use, and to what extent can they be addressed by CHWs and SP+?

Study Design

A cluster-randomized, controlled, mixed-methods trial design was used to evaluate the process and impact of the SP+ intervention. I employed a combination of both qualitative and quantitative data collection methods. These two ‘strands’ of the study were conducted concurrently, and findings from each were interpreted in relation to one another. As outlined below, some participants participated in both qualitative and quantitative phases of the study.

Study Participants

We recruited three groups of participants into the study: CHWs, their facility-based (clinician) supervisors, and their female clients (intended beneficiaries of SP+).

a) CHWs:

All CHWs working in one of the two target areas who completed the national iMNCH training program were eligible to participate. CHW pairs from 32 randomly selected villages (N = 64) were recruited through the Ministry of Health iMNCH training program and invited to participate at the end of the three-week training period. All 64 invited CHWs agreed to participate. Participants provided written informed consent and completed a baseline survey at enrolment. World Vision program staff facilitated this process, however the consent process and data collection occurred independently of WV.

b) CHW supervisors:

Supervisors were eligible to participate if they were full-time employees at a health facility, and a designated supervisor of one or more CHWs enrolled in the study. Supervisors from each of the fourteen facilities in study catchment areas were invited participate (N = 14).

c) Women clients:
Eligible women clients were: a) between the ages of 16 – 49 years; b) pregnant during the intervention period; c) visited at least once during their most recent pregnancy by a CHW who completed the iMNCH/SP+ training sessions; and e) mother to a living child aged 9 months or less.

Development of study instruments

All study tools were developed with inputs from World Vision staff and other colleagues working on MNCH projects in Tanzania. I referred to the SUSTAIN Performance Measurement Framework during this phase, to ensure that relevant monitoring and evaluation indicators were captured in surveys and consistently defined. Most of these indicators reflected definitions used by the Demographic and Health Survey (DHS) Program.

Well-designed likert scales are a useful method of quantifying latent constructs such as participant attitudes, which cannot be directly observed (Aday and Cornelius 2006). Despite their utility, likert scales are vulnerable to three sources of bias: central tendency bias (avoidance of extreme response categories), social desirability bias, and acquiescence bias (when participants tend to agree with statements as they are articulated by the interviewer) (Podsakoff et al. 2003). To minimize the potential for acquiescence bias, we ensured a balance of positively and negatively phrased questions (Aday and Cornelius 2006), and carried out a thorough instrument piloting and refinement process for all likert scales described below.

Two likert-scale surveys were developed to measure CHW job satisfaction and perceived self-efficacy for fulfilling job expectations. The former was adapted from the widely used Job Descriptive Index (JDI), initially developed by Smith, Kendall, and Hulin (1969). Relevant scales from the 2009 edition (Bowling Green State University 2009) were modified from “yes/no” questions to scalar questions in order to better capture variation in answers. After extensive pre-testing and careful adjustment of items to reflect local interpretations in Swahili, we arrived at a 48–item scale covering three main aspects of CHW work: overall satisfaction, day-to-day duties, and supervision.

18 http://dhsprogram.com/
Similarly, an 18-item scale was developed to measure perceived self-efficacy for fulfilling job expectations. As a starting point, I referred to the “Community Health Worker Tool Kit” developed by Meister et al. (1998), which includes a variation of the General Self-efficacy Scale (GSE), used previously in Tanzania. Items on this scale were modified to reflect the context and proposed study objectives prior to pre-testing. Both job satisfaction and self-efficacy scales were administered during face-to-face interviews with CHWs. Through the pre-testing process we found that participants were more confident in their answers when response options were listed in front of them, so we created a cue card system whereby CHWs selected one of five cards to answer each item (e.g. “always”, “sometimes”, “never” etc.). This strategy improved the reliability of responses because it meant that respondents could spend less time trying to remember various response options and instead focus on which one was most appropriate for a given survey item.

Two additional likert-scale surveys were developed for supervisors and women clients to produce composite scores on CHW performance. The client survey included 14 items capturing women’s opinions regarding CHW knowledge and competencies in MNCH, the quality of CHW relationships with clients and their families, and overall satisfaction with CHW services. The 22-item scale for supervisors covered similar topics, plus several items on supervisory observations (e.g. quality of reporting, rapport with clients).

The household survey instrument was developed in collaboration with SUSTAIN project management with reference to existing surveys previously conducted in Singida Region\(^1\). Proxy measures of socioeconomic status included water source, and toilet type, but not household income because we anticipated that asking women directly about income would yield uncertain precision and validity. Education was measured as an independent predictor, however education may also serve as a crude proxy for socioeconomic status. The survey was programmed into Open Data Kit (ODK)\(^2\) software and administered via electronic tablets, which minimized data entry errors and ambiguities. When piloting both paper-based and

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\(^1\) Many of the survey items used by WV in the SUSTAIN baseline survey were derived from internationally standardized Demographic and Health (DHS) surveys.

\(^2\) ODK is “a free and open-source set of tools which help organizations author, field, and manage mobile data collection solutions” ([https://opendatakit.org/](https://opendatakit.org/)).
electronic versions of the survey we found that tablets were more efficient, user-friendly, and were widely accepted by respondents.

Early on, I recognized that women’s decision to utilize maternity services would depend on various facility-level factors that would be difficult to control for by way of study design. Such “fixed” variables include: facility staffing, level of training received by facility staff, quality of services provided, and stock levels of essential medical supplies/equipment at each facility, among others. To account for these potential effects, I developed multivariate measures, derived from previously validated tools, to assess two dimensions of quality of care: 1) perceived quality of the nearest facility according to women, captured by likert-style questionnaires; and b) quality of facilities as measured by researchers using a 47-item health facility checklist\textsuperscript{21}.

Qualitative SSI and FGD guides were designed to capture more nuanced contextual information related to the above topics. SSI and FGD guides aimed to provoke detailed discussions regarding client and supervisor experiences and interactions with CHWs, local pregnancy/childbirth practices and preferences, and perceived barriers to maternal health service utilization. An additional section, related to CHWs’ use of smartphones, was included for FGDs and interviews in SP+ villages. The qualitative interview guide for CHWs included open-ended questions designed to elicit rich narratives regarding CHWs’ opinions and lived experiences with respect to working on RMNCH in their communities. Questions were developed with reference to findings from existing literature, and covered topics such as motivators and deterrents, use of job aids, training, relationship with NGO staff and clinical supervisors, engagement with and support from community members, and opinions regarding the value of CHW work.

Interview and FGD guides were carefully crafted to include only neutral, non-biased language. We also made an effort to ask non-leading questions to avoid influencing participant responses. In FGDs, we avoided singling women out individually by beginning with questions like “Are women in your community satisfied with the quality of care and services offered by CHWs?”

\textsuperscript{21} Adapted from relevant items on The Rapid Health Facility Assessment (R-HFA) tool; an “instrument for measuring a small set of key indicators to give a "balanced scorecard" for MNCH services at the primary health care level” (USAID and MCHIP 2016).
rather than, for example, “Are you satisfied with the quality of care…” This approach aimed to help participants feel more comfortable to speak candidly about shared opinions, and encourage them to share rich insights and personal perspectives. When participants did discuss their personal experiences, we used gentle follow-up questions to encourage others to share individualized accounts as well (e.g. “has anyone had a similar experience?” Do you agree with that? How does your own experience compare?”).

Survey, interview and FGD guides were translated into Kiswahili by local research assistants, then pre-tested with women, CHWs and supervisors at Ilongero Health Centre in Singida, a health facility within the SUSTAIN project catchment area but outside of SP+ study districts. Tools were modified where appropriate to suit local language, literacy levels, and cultural interpretations. All study tools can be found in Appendix B.

**Intervention Allocation**

The SP+ intervention was implemented in two SUSTAIN project districts, Singida Rural and Iramba. In each district, World Vision Tanzania operates area development program (ADP) offices. Each ADP office has a catchment area of 19 villages, therefore the sampling frame for the study consisted of 38 villages in total, all of which were covered by the SUSTAIN project. The mHealth intervention was implemented in ADP areas so that ADP staff could offer technical support during the intervention period if necessary. In addition, we reasoned that if SP+ was effective and World Vision wanted to expand the program in the future, the potential for scale-up would be greater in areas where regular ADP programs were already well established.

Thirty-two Nokia X2-02 smartphones were randomly allocated to 16 pairs of CHWs (2 in each village). An additional 16 villages and CHW pairs were randomly assigned to the control

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22 World Vision ADPs are typically set up in areas with very high need (i.e. low economic, health and development indicators) and remain in this area for 15 years. The goal of this approach is to allow enough time for community engagement with programs so that by the time ADP projects close out, the community has found ways to sustain project activities (and resulting behaviour changes) independently.

23 The number of smartphones was determined by SUSTAIN project staff at WVC based on budget and feasibility considerations.

24 Villages typically have a at least 2 CHWs, usually one male and one female.
group (total N = 64). Group assignment was unmasked. In each district, we selected intervention villages for inclusion in the study using a 3-step protocol: (i) A computer-generated simple randomization procedure was used to select 3 (out of a possible 19) villages to exclude from the study; (ii) The remaining 16 villages were matched based on population size; (iii) For each pair of matched villages, one was randomly allocated to the experimental arm and the other to the control arm.

![Figure 5. Allocation of the Smartphone Intervention (cluster randomized design)](image-url)
Sampling and recruitment

Sample size calculation for household surveys:

The required sample size for household surveys was estimated using methods outlined by Campbell et al (2004). In this paper, authors emphasize the importance of accounting for the effect of clustering on sample size. This can be achieved statistically by using an appropriate intra-cluster correlation coefficient (ICC) value, which is based on the ratio of the between-cluster to within-cluster variance for a given outcome of interest. To identify a suitable ICC, I reviewed the literature on cluster RCTs that measured skilled birth attendance as a main outcome. I was unable to identify any Tanzanian studies of skilled/facility-based delivery that published an ICC value, so I searched for relevant studies published in neighbouring countries as the next best option. By taking the average ICC from two studies from Malawi (cited in Pagel et al. 2011), I determined that an appropriate ICC estimate was 0.14. Using the equation outlined by Campbell et al. and assuming 32 villages (clusters), I calculated a total sample size of 596 women (298 in each study arm). This sample size would allow for detection of a 12% difference between the experimental and control groups, at a 5% significance level and 80% power. I anticipated a 30% loss to follow-up (due to travel, relocation, illness or other causes) and planned to oversample accordingly. Based on these calculations, we aimed to recruit 24 women from each village (12 from each CHW list).

Sampling and recruitment for household surveys:

I used the following sampling protocol to select women for household surveys:

With assistance from WV field staff, I obtained complete lists of clients meeting study inclusion criteria from each CHW prior to data collection. If a CHW had more than 12 eligible women on their list, I prioritized those with longer exposure time (i.e. visited by a CHW prior to 6 months gestation). I then randomly selected from remaining client names until N = 12 for each CHW. If a CHW had 12 eligible clients or fewer, we recruited all of them to participate. In these cases, to reach the target of N = 24 for each village, we compensated by selecting extra clients from the second CHW’s list.
If a selected client was not present (e.g. travelling or unreachable\textsuperscript{25}) the day of the survey, data collectors made at least one re-visit attempt before categorizing them as a non-respondent. If the client was still unreachable after the second visit, or had permanently relocated, then they were replaced with another randomly selected client, if possible. In the control group, 8 women (3.0\% of the control sample) from three villages were replaced, and in the SP+ group, 13 women (4.3\% of the SP+ sample) from five villages were replaced. Overall, 3.7\% of study respondents were replacements. In 24 of 32 villages, the final updated lists of eligible women was less than 24, therefore all women were interviewed.

*Sampling and recruitment of women for focus group discussions (FGDs):*

The following protocol was followed to recruit women for FGDs:

A World Vision staff member requested a complete list of all currently pregnant clients from CHWs working in target villages. If the total number of women was less than or equal to 8, then the CHW invited all of them to participate in the FGD. When the number of women was greater than 8, the research team randomly selected names of women to be invited.

**Data collection procedures**

Data collection occurred over a 13-month period (July 2013 – July 2014), as outlined in Table 2. The first phase involved non-participatory observations and informal discussions during the 3-week iMNCH training module for CHWs. To understand the training process and any anticipated implementation concerns, I also attended the 1-week mHealth training workshop for CHWs, led by D-Tree and facilitated by WVT.

\textsuperscript{25} The most common reasons for women’s absence were a) busy with farming work, often several kilometers from home; b) attending a funeral; c) travelling to visit relatives in neighbouring villages/districts.
Table 2. Data Collection Methods and Samples

<table>
<thead>
<tr>
<th>Data Collection Method</th>
<th>Sample</th>
<th>Data collection point(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Observation of iMNCH and mHealth training sessions for CHWs</td>
<td>64 CHWs</td>
<td>Baseline</td>
</tr>
<tr>
<td>2. Health Facility Assessments</td>
<td>14 Health facilities</td>
<td>6-8 weeks post-baseline</td>
</tr>
<tr>
<td>3. Semi-structured qualitative interviews</td>
<td>60 CHWs (30 control group; 30 SP+ group)</td>
<td>6-8 weeks post-baseline</td>
</tr>
<tr>
<td>4. Quantitative surveys measuring job satisfaction and self-efficacy</td>
<td>59 CHWs</td>
<td>T1: 6-8 weeks post-baseline</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T2: 8 months after T1</td>
</tr>
<tr>
<td>5. Semi-structured qualitative interviews</td>
<td>14 CHW supervisors (facility staff)</td>
<td>T1: 8 weeks post-baseline</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T2: 8 months after T1</td>
</tr>
<tr>
<td>6. Quantitative surveys assessing CHW performance</td>
<td>14 CHW supervisors (facility staff)</td>
<td>9 months post-baseline</td>
</tr>
<tr>
<td>7. Focus Group Discussions</td>
<td>56 women (CHW clients)</td>
<td>T1: 8 prenatal FGDs; 6-8 weeks post-baseline</td>
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<tr>
<td></td>
<td></td>
<td>T2: 4 follow-up FGDs approx. 10 months post-baseline</td>
</tr>
<tr>
<td>8. Household Surveys</td>
<td>574 postnatal women aged 16-49 y</td>
<td>10 months post-baseline</td>
</tr>
</tbody>
</table>

27 12 dispensaries, 2 district hospitals across the two study districts

28 Each health facility had one designated clinician responsible for supervising all CHWs in that facility’s catchment area; thus the number of CHWs reporting to each supervisor varied. The supervisor in each of the 14 facilities completed a performance assessment survey for each CHW reporting to them.

29 These FGDs were conducted with the same participants as in T1, following delivery. We returned to four villages (2 SP+, 2 control) with particularly rich discussions to validate previous findings and explore whether/how perceptions changed over the course of the intervention period.
I hired and trained a team of six qualitative research assistants who had recently graduated from Tanzanian Universities and were fluent in both English and Kiswahili. All had prior experience conducting community-based surveys, and several had extensive experience with qualitative interviewing. To ensure that all team members were comfortable with the qualitative study protocol and data collection techniques, I developed a five-day curriculum on qualitative research skills, which I delivered to the team prior to data collection. The seminar-style course covered topics including effective interviewing and probing techniques, reading and analyzing body language, and managing perceived power dynamics. A significant portion of this time was also dedicated to understanding the qualitative interview scripts and how they reflected specific research questions. The final day of training involved applied learning, whereby participants had the opportunity to practice acquired skills through mock interviews with pregnant women and healthcare providers external to the study population. This also served as a final field test of the survey questionnaire.

Previous ethnographic research on women’s reproductive experiences in rural Tanzania reported that the presence of Caucasian North American-based researchers attracted onlookers, thereby compromising privacy and influencing participant responses (Haws et al. 2010). With this in mind, and following consultation with my local supervisor, Dr. Sebalda Leshabari, we decided that research assistants would be trained to conduct the FGDs with women clients.

An alternative approach would have been for me to collect all data with the assistance of an interpreter, however in the interest of maintaining participant privacy and avoiding response bias, I instead focused my efforts on training Tanzanian research team members to collect data for this study. We reasoned that this would be particularly important for the FGDs with women, as these participants have typically had little or no interactions with Western-based researchers, and discussions took place at the village level, where interruptions from other villagers would be common. Research assistants conducted a majority of the semi-structured interviews (SSI) with CHWs independently, however I sat in on approximately one third of these interviews (N = 20, randomly selected) as a quality control measure. I was present for interviews with clinic staff/supervisors, and led these discussions with the assistance of a research assistant/interpreter, as these interviews were conducted in rooms at health facilities where privacy could be guaranteed.
Following each SSI and FGD, I led in-depth debriefing meetings with interviewers and facilitators to ensure that data collection occurred according to protocol and that appropriate techniques (probing, judging tone of voice etc.) were used. These de-briefing meetings lasted anywhere from 30 to 90 minutes per SSI/FGD, depending on the richness and complexity of each discussion. In addition, the sessions facilitated iterative data reconciliation and analysis, as we could discuss emergent themes together as a team, and examine parallels and contrasts between narratives. FGDs and SSIs were recorded with the permission of participants. Oftentimes it was useful to play back the audio recording during de-briefing meetings so that interviewers could highlight subtleties in the discussion that would otherwise be difficult to convey out of context (changes in tone of voice, bouts of laughter, for example).

Semi-structured one-on-one interviews were conducted with 30 CHWs from experimental villages, and 30 CHWs from control villages between 6-8 weeks after the mHealth training session. The interview guide was comprised of close-ended, Likert-style questions assessing job satisfaction and self-efficacy, as well as open-ended qualitative questions regarding CHW experiences and perceptions of women’s access to maternal health services. The same quantitative scales were repeated at the end of the study to examine changes in job satisfaction and self-efficacy over time.

Initial FGDs with clients were conducted with a randomly selected sub-sample of pregnant women in 4 control villages and 4 experimental villages. We purposefully selected “best case scenario” villages where CHWs were thought to be highly active. This enabled us to document experiences of women in areas where both paper-based and electronic counselling protocols were working well. Follow up FGDs were conducted with 4 of the 8 groups of women to validate findings. FGDs with were conducted in private, central meeting locations, accessible by all participants (e.g. at a church, school, or village office) and each lasted between two to three hours.

A team of ten enumerators was trained to administer postnatal, tablet-based household surveys to women in selected villages. Women were asked a series of questions related to service utilization, including where they delivered their most recent child. Interviewers confirmed this information by checking participants’ clinic cards whenever possible. Household surveys were conducted in private, independent of CHWs and World Vision staff and lasted between 60-90
minutes each. At the end of each survey, the tablet captured the GPS coordinates of participants’ homes, which was used to calculate distance to the nearest health facility. SSIs with supervisors were conducted in private rooms at health facilities and each lasted approximately one hour.

Loss to Follow-Up

Two CHWs from different villages (both SP+ villages in Iramba district) dropped out of the study shortly after the iMNCH training seminar due to conflicting household responsibilities, and thus were not actively engaged with CHW duties throughout the study period. In these cases, which resulted in only a single CHW active in each of the two clusters, we sampled only from the remaining CHW’s client lists for household surveys. Furthermore, a pair of CHWs from a cluster control village in Iramba village did not perform any CHW duties following their training, expressing concerns about lack of compensation for their work. We excluded this village from the household survey because women were not exposed to either of the two interventions, and replaced this cluster-control group by randomly selecting one of the previously excluded villages for inclusion in the household survey. This was deemed a conservative approach to estimating the impact of SP+.

Data Analysis

Analysis of qualitative and quantitative data occurred simultaneously. I employed an iterative analytical procedure whereby findings in one data set could be verified or disputed, explored and contextualized using the other. This process of data triangulation is believed to enhance of the validity and credibility of evaluation results (Creswell and Plano Clark 2011).

Qualitative transcripts:

As a quality assurance measure, I oversaw a multi-stage process of transcription and translation, with a different bilingual research assistant responsible for each step, as follows: 1) one RA transcribed recorded Swahili interviews verbatim; 2) a second RA translated Swahili transcripts into English; and 3) a third RA was responsible for cross-checking the data by listening to the original Swahili recording while reading along in English. Discrepancies were discussed and resolved as a team during weekly research meetings.
I applied a combination of qualitative analytical techniques described by Creswell (2011), Hsieh and Shannon (2005), and Saldana (2013). Generally, qualitative analysis is based on inductive approaches to derive meaning; that is, patterns and themes are developed “from the ground up” and findings are emergent rather than prescriptive (Creswell 2013). However, it can also be helpful to draw from existing literature, theory or frameworks to build on concepts that have been studied by other scholars (Hsieh and Shannon 2005). Since interviews and FGDs aimed at answering several research questions and spanned multiple topics, I used an iterative approach to incorporate both inductive and deductive analytical strategies, as described below.

Interview and FGD transcripts were coded using Nvivo for MAC software, version 10.2.1. The first phase involved the use of conventional content analysis. This approach is typically employed when existing theory and literature on the subject under study is limited (Hsieh and Shannon 2005). I chose this as a starting point because of the relative dearth of research on the complexities of mHealth implementation in Tanzania. With conventional content analysis, researchers try to avoid forcing data into preconceived categories. Rather, the researcher searches for patterns in the data and theme development tends to emerge from the data (Kondracki, Wellman, and Amundson 2002). As I read through the transcripts, I paid special attention to statements relating to the presence/use of smartphones, reactions to the intervention, experiences interacting with the technology, and so on. I used Nvivo’s memo and annotation functions to document my thought processes, initial interpretations, and to make note of common narratives. These detailed analytic memos were also used to summarize emergent themes, formulate hypotheses and highlight particularly rich narratives warranting further exploration (Strauss and Corbin 1998). Conventional content analysis proved particularly useful when applied to data that emerged from open-ended questions and probes, such as “what do you think about this?” and “can you tell me more about that experience?”. This procedure was valuable as a ‘first pass’ through transcripts because I was able to familiarize myself with the data while identifying unexpected findings.

After this initial phase, I parsed the transcripts in a more structured manner. Following the methodology outlined by Saldaña (2013) I adopted a multi-staged coding approach. During a preliminary coding cycle, a general framework (Table 3) was used to “chunk” data into sections according to broad, pre-determined topics, based on interview guides and field notes captured during de-briefing meetings with interviewers. In some ways, this process was indirectly
informed by existing research, as the interview questions were developed following my initial review of the literature and hypothesis generation. An important part of this process was referring back to the initial logic model (Figure 4) to verify, refute, and add to components of this pathway that were captured in qualitative transcripts. As Hsieh and Shannon (2005) note, this method of directed content analysis is most appropriate when “existing theory or prior research exists about a phenomenon that is incomplete or would benefit from further description” (p. 1281). While study objectives related specifically to the implementation of SP+, interviews and FGDs also explored several related areas of inquiry, which were better represented in the existing literature. For example, a growing body of research has explored factors affecting CHW motivation and retention, and women’s utilization of maternal health services. Consequently, it made sense to draw from existing research on these subjects so that comparisons and contrasts could be made.
Table 3. General framework used to guide coding in a directed content analysis

<table>
<thead>
<tr>
<th>Qualitative Research Questions</th>
<th>Relevant data source(s)</th>
<th>Directed Content Analysis:</th>
</tr>
</thead>
<tbody>
<tr>
<td>3a. How does SP+ influence CHWs’ motivation and work experience?</td>
<td>CHW interviews; Supervisor interviews</td>
<td>Coding guided by pre-determined topics and categories based on logic model, interview scripts, extant literature</td>
</tr>
</tbody>
</table>
| 3b. Do job satisfaction and perceived self-efficacy differ among CHWs depending on SP+ use? | CHW interviews; Supervisor interviews | - CHW work history narratives  
- CHW daily activities/responsibilities  
- Benefits of working as a CHW (motivators)  
- Challenges working as a CHW (deterrents)  
- Intrinsic/extrinsic motivators  
- Positive work experience - narratives  
- Negative work experience – narratives  
- CHWs: confidence and competence  
- Training needs/gaps  
- Levels of support (NGO, government)  
- Family and community support  
- Perceived value of ICTs/SP+  
- Challenges with ICTs/SP+ |
| 4. How does SP+ influence perceived quality of care among CHWs’ supervisors and female clients? | CHW interviews; Supervisor interviews; Women client FGDs | - CHW/client relationships – positive/negative  
- Community attitudes towards CHWs  
- Perceptions of SP+ - positive/negative  
- Perceived role of SPs in improving MNCH  
- Referral, data management/collection, client education, reporting  
- Level of satisfaction with CHW services  
- Suggestions for improvement |
| 5. What are the barriers and facilitators of maternal health services use, and to what extent can they be addressed by CHWs and SP+? | CHW interviews; Supervisor interviews; Women client FGDs | - Awareness of ANC/PNC  
- Perceived importance of ANC/PNC Reasons for home delivery  
- Reasons for facility delivery  
- Access vs. utilization  
- Three delays model: a) delay in decision to seek care; b) delay in reaching care; c) delay in receiving adequate healthcare  
- Specific barriers to service uptake: distance, financial, time allocation, transportation  
- Household gender dynamics  
- Role of CHWs; role of SP+ |

A final coding cycle helped to refine the initial coding framework, collapse and parse out categories as appropriate, and develop a number more specific sub-codes (Saldaña 2013). The
framework was continually revised as I worked through the data until I arrived at a final coding
tree. At the same time, iterative assessment of both the coding framework and analytic memos
made throughout the process led to the development of conceptual maps outlining major themes
and dominant constructs relevant to each research question.

As coded transcripts were analyzed, I paid particular attention to whether participants were from
control villages or experimental (SP+) villages. By comparing code frequencies, and the content
of direct quotes from participants in each study arm, I searched for major differences between
the two groups. While the aim was not to quantify differences in this stage of the research,
identifying broad contrasts within the qualitative findings was useful in generating hypotheses
that could be further tested with quantitative data. Once transcripts were coded, results were
summarized and displayed in spreadsheets organized by themes and sub-themes. I interpreted
data with reference to coding summaries, contextual field notes, memos and annotations, and
descriptive data provided by direct quotes from participants.

As themes emerged from the qualitative data, I had the opportunity to hold feedback meetings
with CHWs (organized with the assistance of WVT) where participants could validate, confirm
and/or elaborate on emergent findings, and clarify any contradictory results. This collaborative,
iterative approach to data analysis enabled researchers and participants to co-produce
knowledge, which I believe helped to foster a sense of shared contribution to, and ownership of,
the research project.

**Likert-scale data:**

Simple composite scores were calculated based on CHW, client, and supervisor responses to
Likert-scale questions administered at the beginning of each respective interview (Appendix B).
For a positive item, “strongly agree” was assigned a score of 3 and “strongly disagree” was
assigned a score of 0; conversely, for negative items, these responses were assigned a score of 0
and 3, respectively. An overall composite score was calculated for each scale, for each
participant, by taking the average of all individual item scores. Independent-samples t-tests were
run for each scale to ascertain differences in client assessments of CHWs in control versus SP+
villages. Chronbach’s Alpha was calculated to measure internal consistency and determine the
validity of the scales (Table 4) (Gliem and Gliem 2003). All statistical analyses were completed using SPSS for MAC software, version 22.0.

Table 4. Constructs measured using Likert scale surveys

<table>
<thead>
<tr>
<th>Data Source</th>
<th>Construct Measured</th>
<th>N</th>
<th>Chronbach's Alpha</th>
<th>Interpretation: level of internal consistency</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHW supervisors</td>
<td>CHW Performance</td>
<td>59</td>
<td>0.96</td>
<td>High</td>
</tr>
<tr>
<td>(May/June 2014)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHWs (T1 - Sept/Oct 2013)</td>
<td>Self-efficacy</td>
<td>59</td>
<td>0.90</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Job Satisfaction only</td>
<td>59</td>
<td>0.84</td>
<td>Good</td>
</tr>
<tr>
<td></td>
<td>Supervision questions only</td>
<td>59</td>
<td>0.83</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Job Satisfaction + supervision</td>
<td>59</td>
<td>0.87</td>
<td>Good</td>
</tr>
<tr>
<td></td>
<td>questions only</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHWs (T2 - May/June 2014)</td>
<td>Self-efficacy</td>
<td>60</td>
<td>0.91</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Job Satisfaction only</td>
<td>60</td>
<td>0.88</td>
<td>Good</td>
</tr>
<tr>
<td></td>
<td>Supervision questions only</td>
<td>60</td>
<td>0.83</td>
<td>Good</td>
</tr>
<tr>
<td></td>
<td>Job Satisfaction + supervision</td>
<td>60</td>
<td>0.91</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>questions only</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women clients (June 2014)</td>
<td>CHW performance/quality of care</td>
<td>572</td>
<td>0.92</td>
<td>High</td>
</tr>
<tr>
<td>Women clients (June 2014)</td>
<td>Health Facility Quality Assessment</td>
<td>572</td>
<td>0.79</td>
<td>Good</td>
</tr>
</tbody>
</table>

Quantitative household survey data:

*Variable transformation*

30 Responses coded as “unsure” were treated as missing values. The Chronbach’s alpha package was run in R because this program applies *pairwise deletion*, which minimizes data loss (as opposed to SPSS which performs list wise deletions).
Raw data for ‘scored’ variables (perceived quality of CHW care, health facility quality assessment) were converted to z-scores for analysis in order to normalize responses. Similarly, I used the log-transformed values of raw distance data (in kilometers) to correct for skewedness (Weinberg and Abramowitz 2008). A full list of quantitative variables used in GEE analyses are defined in Table 5 below.

Following initial exploratory analyses, and with reference to existing literature, it was evident that some indicators would be more usefully represented as composite variables. For example, both parity and previous facility delivery experience are important independent predictors of facility-based delivery, but these variables become even more informative when combined. For this reason, I created a composite variable to group participants into several groups: a) primiparous women (first time mothers); b) multiparous women with previous experience delivering in a health facility; and c) multiparous women who have never delivered in a health facility.

Other indicators were transformed into binary variables based on programmatic or clinical relevance. For example, women were asked how many times they received antenatal care during their most recent pregnancy. The World Health Organization recommends a minimum of four visits, thus I created a binary variable to indicate whether or not women attended the recommended 4 visits.

To arrive at an appropriate “distance from a health facility” variable, I experimented with several different binary cut-offs to differentiate between women living near and far from health facilities. Once distances (in kilometers) were calculated from GPS data, I transformed the raw data into three new binary variables: less than or greater than 1km, less than or greater than 5km, and less than or greater than the median distance from a health facility, for all participants. Using facility-based delivery as the main outcome, I calculated an (unadjusted) odds ratio for each of the three distance scenarios. The median distance variable was the most significant predictor of facility-based delivery (p = < 0.001), therefore this variable was used in further analyses and included in the final GEE model.

A binary variable was created for number of reported visits by a CHW. I chose to bin this variable into two categories as follows: a) visited less than twice; or b) visited two or more
times; based on a rationale that the first interaction with a CHW may have only been a registration event, with limited or no counselling administered by the CHW. In most cases, we would expect to see more counselling occur beginning at the second visit.

Table 5. Derivation of outcome measures and indicators used in GEE Models

<table>
<thead>
<tr>
<th>Main outcome</th>
<th>Variable type (survey)</th>
<th>Household survey item</th>
<th>Variable derivation and coding scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facility-based delivery</td>
<td>Categorical</td>
<td>Delivery location:</td>
<td>Changed to binary:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1. Home</td>
<td>Yes (1) = 2 or 3 or 4 or 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Dispensary</td>
<td>No (2) = 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Health Centre</td>
<td>• Note: “in transit” was binned with facility-based delivery based on the rationale that the woman intended to deliver at a facility</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Hospital</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. In transit</td>
<td></td>
</tr>
<tr>
<td>Individual-level variables</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>Discrete</td>
<td>What is your date of birth?</td>
<td>Calculated from date of birth, in years.</td>
</tr>
<tr>
<td>Education</td>
<td>Categorical</td>
<td>What is the highest level of schooling you’ve completed?</td>
<td>0 = None</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 = Primary</td>
<td>1 = Secondary</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 = Secondary</td>
<td></td>
</tr>
<tr>
<td>Religion</td>
<td>Categorical</td>
<td>What is your religion?</td>
<td>1 = Christian</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 = Muslim</td>
<td>88 = Other</td>
</tr>
<tr>
<td>SES proxy 1 (toilet facility)</td>
<td>Categorical</td>
<td>What type of toilet facilities does your household use?</td>
<td>0 = No facilities, field or bush</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 = Traditional/open pit latrine</td>
<td>1 = Traditional/open pit latrine</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 = VIP latrine or flush toilet</td>
<td>2 = VIP latrine or flush toilet</td>
</tr>
<tr>
<td>SES proxy 2 (water source)</td>
<td>Categorical</td>
<td>What is the main source of drinking water for the household?</td>
<td>1 = Borehole or piped water</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 = protected well or spring</td>
<td>2 = protected well or spring</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 = Rainwater collection</td>
<td>3 = Rainwater collection</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 = Unprotected dug well/spring</td>
<td>4 = Unprotected dug well/spring</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 = Pond, river, stream</td>
<td>5 = Pond, river, stream</td>
</tr>
<tr>
<td>History of obstetric complications</td>
<td>Categorical</td>
<td>In the past, did you ever experience any difficulties or complications while giving birth (with any of your children)?</td>
<td>0 = no</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 = yes</td>
</tr>
<tr>
<td>Parity + facility-based delivery experience</td>
<td>Categorical</td>
<td>a) How many children do you have?</td>
<td>Primiparous = 0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b) Where did you deliver this child? (asked separately for each child)</td>
<td>Multiparous + no prior facility delivery = 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Multiparous + at least one prior facility delivery = 2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Household/community-level variables</th>
<th>Categorical</th>
<th>Select district</th>
<th>1 = Singida Rural</th>
<th>2 = Iramba</th>
</tr>
</thead>
</table>
Distance to the nearest health facility
Distance to the nearest hospital

<table>
<thead>
<tr>
<th>Health system-level variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality of the nearest health facility</td>
</tr>
<tr>
<td>Quality of the nearest health facility</td>
</tr>
<tr>
<td>Quality of CHW care</td>
</tr>
<tr>
<td>Number of CHW visits during pregnancy</td>
</tr>
<tr>
<td>Gestational age at first ANC visit</td>
</tr>
<tr>
<td>Number of ANC visits</td>
</tr>
</tbody>
</table>

**GEE Analysis**

I assessed the effect of SP+ on the primary outcome by comparing differences in the likelihood of home versus facility-based delivery (binary outcome) in each study arm. Deliveries in transit (on the way to a facility) were grouped with institutional deliveries as it was reasoned that these women intended to deliver at a facility. The Generalized Estimating Equations (GEE) extension of the logistic regression model with exchangeable covariance structure was used to account for clustering of subjects within villages. GEE models were selected because they control for inter- and intra-cluster correlation, allow independent variables to be correlated, and they offer a more conservative analytical approach than Generalized Linear Mixed Models (GLMM) (Burton,
Gurrin, and Sly 1998). All statistical analyses, including descriptive summaries and GEE regression models were completed using SPSS for MAC software, version 22.0, with the exception of Chronbach’s Alpha, which was run using R. All analyses were performed by intention to treat.

The first model included all variables believed to influence women’s delivery location\(^{31}\), including two-way interactions. Models were built in a backwards step-wise progression as follows: All individual-level factors (e.g. age, education, religion) were added to the model. I ran the model then removed all non-significant variables (p > 0.05). Next I added all community-level factors (e.g. district, distance from HF), ran the model and removed all non-significant variables. Finally, I added in all health-systems related variables (e.g. health facility quality, CHW scores) and repeated the same process to arrive at a final, reduced model. Lastly, I disaggregated data by study district and repeated the entire analytic procedure independently for Singida Rural and Iramba.

In sum, the study design employed a combination of both quantitative and qualitative methodologies to collect data from multiple sources in an effort to triangulate study findings and address research questions from a range of perspectives. The chapters that follow summarize study findings in manuscript form, and therefore include relevant sections of this Methods chapter as appropriate.

\(^{31}\) age, education, parity, religion, socioeconomic status proxies (toilet source, water source), district, previous HF delivery, distance to nearest HF, distance to nearest hospital, history of birth complications, gestational age ANC visit, number of ANC visits, quality of nearest HF (score), number of household visits by a CHW, and perceived quality of CHW care (score).
References


https://www.bgsu.edu/arts-and-sciences/psychology/services/job-descriptive-index.html


Results
Chapter 4 Manuscript #1

Impact of smartphone-assisted prenatal home visits on facility-based delivery: Results from a cluster-randomized intervention study in rural Tanzania

The first manuscript presents the study’s main outcome results and answers research question #1: What is the impact of SP+ on women’s utilization of facility-based delivery (primary outcome)? This manuscript has been prepared for submission to the peer-reviewed journal, *PLoS One*.

In addition to facility-based delivery, World Vision was also interested in the impact of SP+ on a number of secondary outcomes. Initially, I intended to present both primary and secondary outcome results in this manuscript, however during the analysis phase I realized this would be far too much data for one paper, and a manuscript looking only at FBD would be most focused and concise. Therefore, rather than include secondary results in manuscript 1, the unadjusted results are summarized in Appendix C. These results answer research question #2: What is the impact of SP+ on women’s awareness of healthy nutrition practices during pregnancy and delivery, awareness of danger signs during pregnancy, early breastfeeding practices, and postnatal care uptake (secondary outcomes)? Secondary results will be re-visited and incorporated into a separate manuscript at a later date.
Abstract

Background

Ensuring access to safe facility-based delivery (FBD) services is a challenge in rural Tanzania, where 50% of women deliver at home, without assistance from trained clinicians. If properly supported, community health workers (CHWs) may improve women’s demand for and uptake of FBD. Point-of-care mobile phone applications have potential to aid CHW with prenatal counselling, recognition of danger signs, and clinic referrals. While such interventions hold promise, rigorous studies evaluating their impact remain scarce, hence the relevance of this study in the context of persistent challenges to safe motherhood. To our knowledge, this is the first peer-reviewed study looking at the effect of smartphone support for CHWs on FBD. It is also the first mHealth intervention study in a low-income country to explore potential pathways of behavior change.

Methods

A cluster-randomized, controlled comparison design was used to evaluate the impact of a smartphone-based application (SP) designed to assist CHW with data collection, education delivery, gestational danger sign identification, and referrals in Singida, Tanzania. Pairs of CHW in 32 randomly selected villages were cluster-randomized to training on either SP or paper-based protocols for use during household visits with pregnant women. The main outcome (delivery location) was ascertained via postnatal household surveys with 572 randomly selected clients.

Findings

The intervention was associated with increased FBD: 74% of mothers in the experimental arm delivered at or in transit to a health facility (HF), versus 63% in the control arm. After adjusted analyses, the odds of delivering in a health facility were two times greater among women counselled by SP-assisted CHWs than the odds of FBD in the control group (OR, 1.95; p, 0.02). The largest impact was among first-time mothers with low antenatal care (ANC) uptake (N=56); in this group, FBD was 32% higher in the experimental arm (84%). Parity, previous FBD experience, ANC uptake, and presence of a public hospital remained very strong independent...
predictors of FBD in both control and intervention groups. Increased frequency of prenatal home visits by CHWs is one mechanism through which SP+ led to increased FBD.

Interpretation

In this setting, the factors influencing women’s use of FBD are multidimensional. SP support for CHW can be efficacious as one component of intervention packages targeting increased FBD. Results provide a strong basis for further research on cost-effectiveness and potential for scale-up.
Introduction

Since the advent of the Safe Motherhood Initiative nearly twenty years ago [1], leaders in maternal, newborn and child health (MNCH) have called for improved access to skilled medical professionals during labour and delivery. This is driven by evidence that effective provision of high quality facility-based delivery (FBD) services remains the best strategy available for reducing maternal mortality during the intrapartum period, when the majority of maternal deaths occur [2]. Many studies in low and middle-income countries (LMICs) have demonstrated that FBD improves maternal survival rates, as trained medical personnel are well positioned to react promptly in the event of a sudden obstetric complication [3–5]. Despite global recognition of the benefits, ensuring access to safe FBD services remains a challenge in many low and middle-income countries (LMICs), particularly rural areas of south Asia and sub-Saharan Africa [6].

Documented “supply-side” challenges include the scarcity and unequal distribution of properly equipped health facilities and human resources for health, and “demand-side” factors such as household gender dynamics, preference for home birth and/or village-based traditional birth attendants (TBAs), community attitudes towards facility delivery, and low awareness and recognition of pregnancy and obstetric danger signs [7–12].

To improve FBD rates in low-resource settings, existing human resources for health must be leveraged to strengthen links between households and communities, and the formal healthcare system. Frontline community health workers (CHWs), a cadre of peer-elected volunteers trained to deliver basic medical and health promotion services, can be powerful drivers of maternal health service demand, particularly in rural populations [13]. While they cannot replace highly skilled health care professionals, studies have shown that when equipped with appropriate knowledge, experience and skills, CHWs can help to mobilize communities, deliver preventive health education and services, and promote health-seeking behaviours [14]. Of critical importance is their potential to work with families to plan for safe delivery, identify danger signs during pregnancy, and make timely referrals to skilled medical personnel during pregnancy and childbirth.

Despite their potential, in the absence of sufficient training, effective supervision and job aids, CHW performance can be suboptimal, characterized by high error rates and low protocol compliance [14–16]. Issues with equity of service delivery, training and supervision, incentives,
attrition, record keeping and information management are the subjects of ongoing debate among programmers and policy makers globally [17]. To improve the quality of their services, innovative strategies to better support CHWs are needed. The evolving field of mobile health (‘mHealth’) presents some promising solutions in this regard. Broadly, mHealth refers to the use of mobile technologies (cell phones and other information communications technologies) to improve the delivery of, and access to, health services and information [18].

The recent surge in mobile phone use in LMICs has led to increased interest and investment in the use of information and communication technologies (ICTs) for development. MHealth leverages wireless mobile technologies to strengthen health systems through improved delivery and management of evidence-based health interventions [14]. Various countries have piloted, and in some cases scaled up programs that use mobile phone-based approaches to support data collection, emergency medical response, point-of-care diagnostics and support for health workers, and health promotion campaigns [19]. Proponents of mHealth strategies suggest that these simple, low-cost mobile interventions could potentially lead to significant health gains in sub-Saharan Africa, particularly among women and children under five [20].

While mHealth interventions hold considerable promise, rigorous scientific studies evaluating their impact remain scarce [21]. Most existing research on mobile phones as a tool for MNCH behavior change has been conducted in high-income countries [22]. Among the few studies from LMICs, the vast majority report on the effects of health-related SMS (text) messaging on patient health behaviours [23] and to a lesser extent, direct voice support for patients [24,25], or a combination of both [26]. While a number of studies on usability, feasibility and acceptability of mHealth strategies report positive findings, research evaluating the health impacts of cell phone-based strategies for frontline health workers has been mostly descriptive and remains inconclusive [27,28].

Reviews have called for a more robust evidence base for mHealth approaches to inform the design and implementation of MNCH programs, and broader funding and policy-related decision making [29]. At the time of writing, only one published study reports on the impact of mHealth initiatives on skilled birth attendance [27]; and to our knowledge, none have assessed whether point-of-care support systems for frontline health workers can improve FBD. The
present study aims to help fill this gap by reporting on the impact of a smartphone-based application for CHWs on women’s utilization of FBD in rural Tanzania.

**Programmatic context and study setting**

In the present study, we sought to evaluate an intervention aimed at increasing women’s demand for, and utilization of, FBD services within the context of a large scale intervention project in Tanzania, where maternal mortality remains high (454/100,000 live births) and only about 50% of deliveries are conducted in health facilities [30]. Striking wealth disparities exist across Tanzania with respect to delivery location: among women in the lowest wealth quintile, 65.5% of deliveries occur at home, versus only 9.5% within the highest quintile. Women with lower education, higher parity, and those living in rural areas are the least likely to access FBD services [12,30,31].

*Supporting Systems to Improve Nutrition, Maternal, Newborn, and Child Health (SUSTAIN-MNCH)* was a three-year project implemented by World Vision Tanzania in two districts of the country’s central Singida Region. The project was funded through the Department of Foreign Affairs, Trade and Development (DFATD) under Canada’s Muskoka Initiative Partnership Program, and led by World Vision Canada. Singida is one of Tanzania’s poorest regions, home to 1.4 million people, 57% of whom fall within the lowest two national wealth quintiles [30]. Further, Singida region has only 158 health facilities, the second lowest in the country after Manyara region, and a high maternal mortality rate (178 per 100,000 live births) [32]. While almost all women in Singida access antenatal care at least once during pregnancy, only 60% attend the recommended 4 ANC visits, and approximately 60% deliver without the assistance of a skilled birth attendant [30,32]. According to a World Vision baseline report, FBD rates in Singida District were lower than in Iramba District prior to SUSTAIN project implementation (54% and 63%, respectively) [33]. Among many activities targeting improved maternal and child health outcomes, the SUSTAIN project aimed to strengthen CHW capacity through roll-out of a smartphone-based application designed as a job aid and to facilitate capture and coordination of information on key maternal, newborn and child health indicators.

**Tanzania iMNCH program background**
Given Tanzania’s fragmented health infrastructure and predominantly rural population (approximately 75% of inhabitants), CHWs provide a crucial link between hard-to-reach communities and the formal health system in this context [34]. At the time of the study Tanzanian national recommendations were for each village health committee to appoint a minimum of two CHWs, one male and one female. These individuals should be elected by their community and are currently expected to work on a voluntary basis. Both the government and NGOs work with and rely on CHWs in various capacities, periodically recruiting them to participate in health promotion or immunization campaigns, and training seminars on specific health topics. When the SUSTAIN project began, most villages in target areas had existing CHWs in place, however their levels of activity, experience, training and expectations varied widely.

In 2012, the Tanzania Ministry of Health & Social Welfare (MoHSW) approved an integrated Maternal Newborn and Child Health (iMNCH) training program for CHWs, in an effort to standardize CHW duties and expectations across the country, and accelerate progress towards Millennium Development Goals 4 and 5 [35]. This three-week curriculum trains community-elected CHWs to make regular household visits to mothers and children at specific times throughout pregnancy, infancy and early childhood to provide education and counselling on birth preparedness, infant feeding and nutrition, the importance of attending antenatal (ANC) clinics, and safe delivery, among other topics. CHWs learn to identify danger signs during pregnancy and following delivery, and to refer clients to health facilities accordingly. To promote healthy behaviours, CHWs are provided with paper-based register books, and photo flipcharts (bango kititas in Kiswahili), which are used as counselling tools during household visits. Prior to implementing the smartphone intervention, all CHWs in SUSTAIN project areas were trained on the iMNCH program.

**The SUSTAIN smartphone application (SP+)**

Aiming to strengthen support for CHWs in SUSTAIN target areas, World Vision collaborated with D-Tree International to develop a smartphone application for use by CHWs during prenatal household visits. The application was developed using CommCare, an open source platform designed specifically to aid development of tools for frontline health workers. The SUSTAIN application was developed in accordance with national iMNCH program guidelines and was
intended for use along with the ministry-developed photo flipbooks during household counselling sessions with clients (combined intervention hereafter referred to as SP+). The application guides CHWs through electronic protocols, directing CHWs to specific health counselling topics and messages based on clients’ gestational age and answers to diagnostic questions. By guiding CHWs through systematic protocols, the application assists with client registration and follow-up, recognition of danger signs during pregnancy and the postpartum period, referral of clients to health facilities, and data management and reporting. It was hypothesized that use of the application as a behaviour change communication tool during prenatal visits would lead to increased utilization of FBD among CHW clients through improved quality of targeted counselling, provision of more standardized care, and improved referral and follow-up.

As research partners, we provided key scientific inputs to WV during the implementation phase, however our team did not develop the intervention, nor did we lead or provide any training on the SP+ intervention. WV developed and deployed the SUSTAIN application independently. Once developed, we were tasked only with evaluating the randomized intervention, and thus were not required to register the study as a trial.

**Methods**

**Ethical considerations**

The Office of Research Ethics at the University of Toronto, Canada, the Tanzanian National Institute for Medical Research (NIMR) and the Tanzanian Commission for Science and Technology (COSTECH) approved the research protocol, and COSTECH issued a research permit to KH to conduct primary data collection in Singida Region. Written permission to conduct the study was obtained from regional, and district-level authorities prior to the start of data collection.

**Evaluation study design**

We used a cluster-randomized, controlled comparison design to evaluate the impact of implementation of the SUSTAIN smartphone (SP) application from August 2013 to June 2014. CHWs from intervention villages in which the SP application was rolled out, (‘SP+’ villages,
that is the experimental arm), were trained to make household visits using the iMNCH photo book and electronic (SP-based) protocols. CHWs from villages in which the SP application was not rolled out (the control arm), used only the iMNCH photo flipbook and standard paper-based protocols. CHWs in both study arms followed their respective protocols for a period of approximately 10 months before postnatal outcome measures were assessed.

Randomization/Intervention Allocation

The intervention was implemented in two SUSTAIN project districts, Singida Rural and Iramba. In each district, World Vision (WV) operates area development program (ADP) offices. The mHealth intervention was implemented in ADP areas so that WV staff could offer technical support during the intervention period if necessary. In addition, if a positive impact was measured, the potential for intervention scale-up would be greater in areas where regular WV programs are already well established. Each ADP office has a catchment area of 19 villages, therefore the sampling frame for the study consisted of 38 villages in total.

Randomization occurred at the village level. Thirty-two mobile phones were randomly allocated to 16 pairs of CHWs (2 in each village). An additional 16 villages and CHW pairs were randomly assigned to the control group (total N = 64). Group assignment was unmasked. In each district, we selected intervention villages for inclusion in the study using a 3-step protocol: (i) A computer-generated simple randomization procedure was used to select 3 (out of a possible 19) villages to exclude from the study; (ii) the remaining 16 villages were matched based on population size (other potential confounders were controlled for during analysis); (iii) for each pair of matched villages, one was randomly allocated to the experimental arm and the other to the control arm.

Study population

We recruited CHWs into the study at baseline, and their female clients at the end of the study period, following delivery. Eligible CHWs had to be working in one of the two target areas and must have completed the national iMNCH training program. Eligible women clients were: a) between the ages of 16 – 49 years; b) pregnant during the intervention period; d) visited at least once by a CHW following the iMNCH/mHealth training, and during their most recent pregnancy; and e) had a live birth.
Sampling & recruitment

CHWs from selected villages (N = 64) were recruited through the iMNCH training program, which WV facilitated in SUSTAIN project areas, and were invited to participate at the end of the three-week training period. All invited CHWs agreed to participate. Participants provided written informed consent and completed a baseline survey at time of enrolment.

Women were recruited for postnatal household surveys at the end of the intervention period, using the following sampling protocol: (i) we obtained from each CHW complete lists of clients meeting study inclusion criteria; (ii) if a CHW had more than 12 eligible women on their list, we prioritized those with longer exposure time (i.e. visited by a CHW prior to 6 months gestation); (iii) we randomly selected from remaining client names until N = 12 for each CHW; (iv) if a CHW had less than 12 eligible clients, we invited all to participate. In these cases, we selected additional clients from the second CHW’s list to make up the difference; (v) in villages where CHWs had more than 24 eligible clients, we randomly selected up to 24 names; (vi) if a selected woman was not present (e.g. travelling, relocated, or unreachable) or found to be ineligible on the day of the survey, we replaced this client with another randomly selected name, if possible.

Outcome measures

The main outcome of interest was FBD. To ascertain this data we conducted postnatal household surveys with a randomly selected sample of eligible mothers. Women were asked whether they delivered at home, a dispensary, a health centre, a hospital, or in transit to a health facility. Interviewers confirmed this information by checking participants’ clinic cards whenever possible. Research team members used tablets to administer surveys in private, independent of CHWs and NGO staff.

Loss to follow-up

Two CHWs from different villages (both experimental villages in Iramba district) dropped out of the study shortly after the iMNCH training seminar due to conflicting household responsibilities, and were not actively engaged with CHW duties throughout the study period. In these cases, which resulted in only a single CHW active in each of the two clusters, we sampled only from the remaining CHW’s client lists for household surveys. Furthermore, a pair of
CHWs from the same cluster control village did not perform any assigned tasks following training, expressing concerns about lack of compensation for their work. We excluded this village from the household survey because women were not exposed to either of the two interventions, and replaced this cluster-control group by randomly selecting one of the previously excluded villages for inclusion in the household survey. This was deemed a conservative approach to estimating the impact of the SP intervention since including a village with no CHW activity would likely result in underestimating the relative influence of paper-based iMNCH protocols.

Women who fit study inclusion criteria but whose child had died since delivery were excluded from the study, as it would be unethical to discuss pregnancy and childbirth experiences following such a loss. These cases were reported to WV and CHWs, who followed established protocols for district health system reporting.

**Measurement of potential confounding factors**

Proxy measures of socioeconomic status included water source, and toilet type, but not household income because we anticipated that asking women directly about income would yield uncertain precision and validity. To account for the potential confounding effect of health facility quality, we developed multivariate measures, derived from previously validated tools, to assess two dimensions of quality: 1) perceived quality of the nearest facility according to women, captured by Likert-style questionnaires; and b) objective quality of facilities as measured by researchers using a 47-item health facility checklist. All study tools were pre-tested and modified accordingly prior to use.

**Data Analysis**

We assessed the effect of smartphones on the primary outcome by comparing differences in the likelihood of home versus FBD (binary outcome) in each study arm. Deliveries in transit (on the

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32 Adapted from relevant items on *The Rapid Health Facility Assessment (R-HFA)* tool; an “instrument for measuring a small set of key indicators to give a "balanced scorecard" for MNCH services at the primary health care level". 
way to a health facility) were grouped with FBDs, based on a rationale that these women intended to deliver at a facility (analogous to analysis by “intention to treat”). The Generalized Estimating Equations (GEE) extension of the logistic regression model with exchangeable covariance structure was used to account for clustering of subjects within villages. Statistical analyses were completed using SPSS for MAC software, version 22.0. All analyses were performed by intention to treat.

We fitted an initial model including all variables believed to influence women’s delivery location\textsuperscript{33}, including two-way interactions. Models were built in a backwards step-wise progression as follows: (i) all individual-level factors (e.g. age, parity, religion) were added to the model; (2) we ran the model then removed all non-significant variables (p > 0.05); (iii) we added all community-level factors (e.g. district, distance from HF), ran the model and removed all non-significant variables; (iv) finally, we added in all health-systems related variables (e.g. quality of HF/CHW scores) then removed any insignificant variables to arrive at the final reduced model. This procedure was repeated independently for each study district.

Results

Achieved Sample Size

A total of 572 postnatal household surveys were conducted with women clients. A team of ten interviewers conducted surveys over a three-week period in June 2014. The study flow diagram, including sampling strategy and achieved sample sizes by district and study arm are outlined in Figure 1.

\textsuperscript{33} age, parity, religion, socioeconomic status proxies (toilet source, water source), district, previous FBD, distance to nearest HF, distance to nearest hospital, history of birth complications, timing of first ANC visit, number of ANC visits, quality of nearest HF (checklist score), number of household visits by a CHW, and perceived quality of CHW care (score).
Figure 1: Study Flow Diagram Outlining Sample Size Achieved in each study arm and district.

Descriptive Characteristics

Sociodemographic profiles of women in SP+ and control groups are presented in Table 1. A majority of women in both groups had primary school education. Of those who specified a religion, the split between Christian and Muslim was not significantly different between intervention and control groups. Most women lived within the median distance (3.3 km) from the nearest health facility, and the vast majority lived further than the median distance (10.2 km) from a hospital. While median distances did not differ between study groups, a significantly higher proportion of women in the control group (77%) lived close (defined as < 5km) from the
nearest health facility, compared to 67% of women in the SP+ group (p = 0.02, assessed by Pearson’s X² test).

Table 1. Sociodemographic profiles of women participating in household surveys

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Intervention (N = 304)</th>
<th>Control (N = 268)</th>
<th>p-value³⁴</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Demographics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maternal age, y (mean, SE)</td>
<td>28.2 0.4</td>
<td>29.1 0.4</td>
<td>0.12</td>
</tr>
<tr>
<td>Infant age, mo (mean, SE)</td>
<td>3.2 0.1</td>
<td>3.0 0.1</td>
<td>0.29</td>
</tr>
<tr>
<td><strong>Religion</strong>³⁵ (N, %)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Christian</td>
<td>194 64.0</td>
<td>157 61.6</td>
<td>0.56</td>
</tr>
<tr>
<td>Muslim</td>
<td>109 36.0</td>
<td>98 38.4</td>
<td></td>
</tr>
<tr>
<td><strong>Highest level of schooling</strong> (N, %)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>39 12.8</td>
<td>50 18.7</td>
<td></td>
</tr>
<tr>
<td>Primary</td>
<td>252 82.9</td>
<td>102 75.4</td>
<td>0.15</td>
</tr>
<tr>
<td>Secondary</td>
<td>13 4.3</td>
<td>16 6.0</td>
<td></td>
</tr>
<tr>
<td><strong>Water source</strong> (N, %)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Access to closed/protected source</td>
<td>134 44.1</td>
<td>98 36.6</td>
<td>0.07</td>
</tr>
<tr>
<td>Unprotected/open water source</td>
<td>170 55.9</td>
<td>170 63.4</td>
<td></td>
</tr>
<tr>
<td><strong>Type of toilet facilities</strong>, (N, %)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VIP latrine or flush toilet</td>
<td>0 0.0</td>
<td>1 0.4</td>
<td></td>
</tr>
<tr>
<td>Traditional/open pit latrine</td>
<td>299 98.4</td>
<td>265 98.9</td>
<td>0.35</td>
</tr>
<tr>
<td>No facilities, bush or field</td>
<td>5 1.6</td>
<td>2 0.7</td>
<td></td>
</tr>
<tr>
<td><strong>Distance from the nearest health facility (km)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean, SE</td>
<td>3.8 0.1</td>
<td>3.4 0.1</td>
<td>0.09</td>
</tr>
<tr>
<td>Median, SD</td>
<td>3.5 2.4</td>
<td>3.2 2.1</td>
<td>0.32</td>
</tr>
<tr>
<td><strong>Distance (km) from nearest hospital</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean, SE</td>
<td>11.3 0.4</td>
<td>12.1 0.5</td>
<td>0.14</td>
</tr>
<tr>
<td>Median, SD</td>
<td>9.1 6.4</td>
<td>10.7 7.5</td>
<td>0.03</td>
</tr>
<tr>
<td><strong>Obstetric Risk Indicators</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parity (mean, SE)</td>
<td>3.6 0.4</td>
<td>3.96 0.1</td>
<td>0.04</td>
</tr>
<tr>
<td>Parity prior to most recent birth (N, %)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nullipara (0 previous births)</td>
<td>62 20.4</td>
<td>47 17.5</td>
<td>0.40</td>
</tr>
<tr>
<td>Multipara (1 or more births)</td>
<td>242 79.6</td>
<td>221 82.5</td>
<td></td>
</tr>
<tr>
<td>Previously delivered at least one child in a HF</td>
<td>214 70.4</td>
<td>193 72.0</td>
<td>0.78</td>
</tr>
<tr>
<td>History of obstetric complication</td>
<td>46 15.1</td>
<td>37 13.8</td>
<td>0.64</td>
</tr>
<tr>
<td>ANC visits for most recent child (N, %)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

³⁴ Significance assessed by Independent samples t-tests, or Pearson’s chi-squared tests

³⁵ Of those women who specified a religion (N=558)
Impact of SP+ on facility-based delivery

Overall, the SP intervention had a positive effect on FBD: 74% of mothers in the experimental group delivered at or in transit to a health facility, versus 62% in the control group (Table 2). Among women who delivered at a facility, 71% did so at a hospital. Of these women, 65% had bypassed a nearer health facility (dispensary or health centre) to deliver at a hospital.

Table 2. Location of birth following exposure to each intervention

<table>
<thead>
<tr>
<th>Reported Delivery Location(^{36}) (%)</th>
<th>Total (N = 572)</th>
<th>SP+ (N = 304)</th>
<th>Control (N = 268)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home</td>
<td>31.6 181 26.3</td>
<td>37.7 101</td>
<td>80 28</td>
</tr>
<tr>
<td>Dispensary</td>
<td>10.5 60 10.5</td>
<td>10.4 28</td>
<td></td>
</tr>
<tr>
<td>Health Centre</td>
<td>8.0 46 9.2 28</td>
<td>6.7 18</td>
<td></td>
</tr>
<tr>
<td>Hospital</td>
<td>44.6 255 47.0</td>
<td>41.8 112</td>
<td></td>
</tr>
<tr>
<td>In transit</td>
<td>5.2 30 6.9 21</td>
<td>3.4 9</td>
<td></td>
</tr>
</tbody>
</table>

For all models, results were expressed as odds ratios (ORs) for FBD with 95% confidence intervals and significance was defined as p < 0.05. In Iramba district, 89.6% of women delivered at or on the way to a facility, compared to only 48.3% in Singida Rural district. After accounting for the effects of village-level clustering and significant predictors of FBD (including district), the odds of delivering at or on the way to a facility were two times greater among women in the SP+ group compared to the odds among women in the control group (Table 3).

---

\(^{36}\) By retrospective report at interview, after delivery; confirmed by cross-checking clinic cards when possible
Table 3. Association between Smartphone Intervention & FBD, by District

<table>
<thead>
<tr>
<th>Stratification</th>
<th>FBD % (N)</th>
<th>Home delivery % (N)</th>
<th>Unadjusted OR (95% CI)</th>
<th>p-value</th>
<th>Adjusted OR (95% CI)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>68.4 (391)</td>
<td>31.6 (181)</td>
<td>1.46 (0.63 - 3.40)</td>
<td>0.38</td>
<td>2.0 (1.10 - 3.48)</td>
<td>0.02</td>
</tr>
<tr>
<td>Intervention</td>
<td>73.7 (224)</td>
<td>26.3 (80)</td>
<td>1</td>
<td></td>
<td>1.46 (0.67 - 2.94)</td>
<td>0.37</td>
</tr>
<tr>
<td>Control</td>
<td>62.3 (167)</td>
<td>37.7 (101)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Singida District³⁹</td>
<td>48.3 (142)</td>
<td>51.7 (152)</td>
<td>1</td>
<td></td>
<td>1.40 (0.67 - 2.94)</td>
<td>0.37</td>
</tr>
<tr>
<td>Intervention</td>
<td>53.3 (80)</td>
<td>46.7 (70)</td>
<td>1.40 (0.67 - 2.94)</td>
<td>0.37</td>
<td>2.0 (0.96 - 3.97)</td>
<td>0.07</td>
</tr>
<tr>
<td>Control</td>
<td>48.3 (62)</td>
<td>56.9 (82)</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Iramba District⁴⁰</td>
<td>89.6 (249)</td>
<td>10.4 (29)</td>
<td>2.53 (0.79 - 8.06)</td>
<td>0.12</td>
<td>1.8 (0.60 - 5.4)</td>
<td>0.30</td>
</tr>
<tr>
<td>Intervention</td>
<td>93.5 (144)</td>
<td>6.5 (10)</td>
<td>2.53 (0.79 - 8.06)</td>
<td>0.12</td>
<td>1.8 (0.60 - 5.4)</td>
<td>0.30</td>
</tr>
<tr>
<td>Control</td>
<td>84.7 (105)</td>
<td>15.3 (19)</td>
<td>1</td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Significant FBD predictors included in the final model are presented in Table 4. The most important maternal predictor was parity combined with previous FBD experience. Multiparous women who had never delivered in a health facility were 33 times less likely to deliver in a facility compared to multiparous women with at least one previous facility delivery. The odds of FBD among primiparae were about the same as the odds among multiparous women who reported at least one previous FBD.

The odds of FBD among Muslim women were 2.8 times greater compared to women who selected “none” for religion, whereas for Christian women, the odds were 1.6 times greater than this group. Quality of the nearest health facility, as measured by researchers using a health

³⁷ Adjusted for village (cluster) effect only
³⁸ Adjusted for village (cluster) effect and significant variables associated with facility-based delivery.
³⁹ Weaker health facility landscape (1 private hospital, 4 dispensaries)
⁴⁰ Stronger health facility landscape (1 public hospital, 1 health center, and 7 dispensaries)
facility checklist, was also a significant predictor of delivery location: for every one-unit increase in quality score, the odds of FBD were 1.6 times greater.

The only significant interaction effect was between ANC uptake and distance from women’s homes to the nearest health facility. When data were stratified by ANC uptake, we found that among women who attended less than 4 visits, the odds of FBD among those living closer to a health facility (< median distance) were twice the odds of FBD among those living further away (> median distance). Among women who attended more than 4 ANC visits, distance did not have a significant impact on facility delivery. Thus, ANC uptake modified the effect of distance on FBD.
Table 4. Reduced GEE model retaining significant predictors of FBD, overall sample (N = 572)

<table>
<thead>
<tr>
<th>Significant predictors retained</th>
<th>Wald Chi-square</th>
<th>Odds Ratio</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Intervention group</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP+ (smartphone protocol)</td>
<td>5.2</td>
<td>1.95</td>
<td>0.02</td>
</tr>
<tr>
<td>Control (paper-based protocols)</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>District</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iramba&lt;sup&gt;41&lt;/sup&gt;</td>
<td>29.8</td>
<td>13.9</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Singida&lt;sup&gt;42&lt;/sup&gt;</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Parity &amp; FBD experience</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primiparous</td>
<td>0.3</td>
<td>0.87</td>
<td>0.60</td>
</tr>
<tr>
<td>Multiparous, no previous HF delivery</td>
<td>37.5</td>
<td>0.03</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Multiparous, at least 1 previous HF delivery</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Religion</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Christian</td>
<td>1.7</td>
<td>1.58</td>
<td>0.19</td>
</tr>
<tr>
<td>Muslim</td>
<td>6.7</td>
<td>2.78</td>
<td>0.01</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ANC Uptake</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low (&lt; 4 visits)</td>
<td>11.6</td>
<td>0.28</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>High (4 or more visits)</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Quality of nearest health facility (z-score)</strong></td>
<td>8.9</td>
<td>1.63</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td><strong>Distance to Nearest Health Facility</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lives near a HF (&lt; median distance)</td>
<td>0.3</td>
<td>0.8</td>
<td>0.612</td>
</tr>
<tr>
<td>Lives far from a HF (&gt; median distance)</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interaction between ANC uptake and distance from nearest health facility</td>
<td>5.6</td>
<td>3.18</td>
<td>0.02</td>
</tr>
</tbody>
</table>

**Differences by District**

The odds of FBD in Iramba district were nearly 14 times greater compared to the odds in Singida Rural District (Table 4). This large discrepancy warranted running independent GEE models for each district, which are outlined in Table 5 and Table 6.

As illustrated in Table 6, several significant predictors of FBD in Singida Rural were less important in Iramba district (ANC uptake, distance to a health facility, quality of the nearest health facility).

<sup>41</sup> Stronger health facility landscape (1 public hospital, 1 health center, and 7 dispensaries)

<sup>42</sup> Weaker health facility landscape (1 private hospital, 4 dispensaries)
facility), however having a history of birth complications was statistically significant. In Iramba, women who reported having a past birth complication five times greater odds of delivering at or on the way to a health facility compared to women who reported no history of birth complications. In one village in Iramba, 13 of the 14 women interviewed selected “no religion” for this indicator. This group was significantly less likely to deliver at a health facility, compared to both Christian and Muslim women.

Table 5. Reduced GEE model retaining significant predictors of FBD in Singida Rural District

<table>
<thead>
<tr>
<th>Significant predictors retained</th>
<th>Wald Chi-square</th>
<th>Odds Ratio</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Intervention group</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP+</td>
<td>5.15</td>
<td>2.06</td>
<td>0.02</td>
</tr>
<tr>
<td>Control</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Parity &amp; FBD experience</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primiparous</td>
<td>0.72</td>
<td>0.73</td>
<td>0.40</td>
</tr>
<tr>
<td>Multiparous, no previous HF delivery</td>
<td>23.6</td>
<td>0.03</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Multiparous, at least 1 previous HF delivery</td>
<td></td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td><strong>Religion</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Religion – Muslim</td>
<td>4.0</td>
<td>1.90</td>
<td>0.05</td>
</tr>
<tr>
<td>Religion - Christian</td>
<td></td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td><strong>ANC uptake</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low ANC uptake (&lt; 4 visits)</td>
<td>11.8</td>
<td>0.22</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>High ANC uptake (4 or more visits)</td>
<td></td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td><strong>Quality of nearest health facility (z-score)</strong></td>
<td>12.75</td>
<td>1.8</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td><strong>Distance to Nearest Health Facility</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lives near a HF (&lt; median distance)</td>
<td>0.27</td>
<td>0.75</td>
<td>0.60</td>
</tr>
<tr>
<td>Lives far from a HF (&gt; median distance)</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td><strong>Interaction between ANC uptake and distance from nearest health facility</strong></td>
<td>4.7</td>
<td>3.82</td>
<td>0.03</td>
</tr>
</tbody>
</table>
Table 6. Reduced GEE model retaining significant predictors of FBD in Iramba District

<table>
<thead>
<tr>
<th>Significant predictors retained</th>
<th>Wald Chi-square</th>
<th>Odds Ratio</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intervention group</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SP+</td>
<td>1.07</td>
<td>1.8</td>
<td>0.30</td>
</tr>
<tr>
<td>Control</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parity &amp; FBD experience</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primiparous</td>
<td>0.05</td>
<td>1.1</td>
<td>0.82</td>
</tr>
<tr>
<td>Multiparous, no previous HF delivery</td>
<td>8.94</td>
<td>0.02</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Multiparous, at least 1 previous HF delivery</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Religion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>religion - Christian</td>
<td>14.21</td>
<td>4.9</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>religion - Muslim</td>
<td>4.40</td>
<td>8.2</td>
<td>0.04</td>
</tr>
<tr>
<td>religion - None</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>History of birth complications</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reported history of birth complications</td>
<td>10.65</td>
<td>5.0</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Reported no birth complications in the past</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Where did smartphones have the greatest impact?

Given the strength of associations between FBD and parity, previous FBD experience, and ANC uptake, these predictors were used to stratify participants into three “high risk” groups: 1) primiparous with low ANC uptake (attended fewer than 4 ANC visits); 2) multiparous who reported no previous FBD, and had low ANC uptake; and 3) multiparous who reported at least one previous FBD and had low ANC uptake.

Of these three groups, smartphones appear to have the greatest impact on FBD among primiparous women who attended less than 4 ANC visits (Figure 2). In this cohort, 84% of women in the experimental group delivered at or in transit to a health facility, compared to only 52% of women in the control group. Similar results were observed among multiparous women who attended fewer than 4 ANC visits. This suggests that even in the absence of high ANC uptake, smartphone counselling by CHWs increased the likelihood of FBD in these two groups.
Figure 2. FBD in each study group, stratified by parity, FBD experience, and ANC uptake.

*Significance assessed by Chi-square tests for proportions

** Significance assessed by Fisher’s exact test for proportions

**Mechanism: How did SP+ lead to increased FBD?**

We hypothesized that women’s reported frequency of CHW home visits might be an intervening factor influencing the observed effect of SP+ on FBD. To test this, a binary variable was created for number of reported home visits by a CHW. We chose to bin this variable into two categories as follows: a) visited less than twice; or b) visited two or more times; based on a rationale that the first interaction with a CHW may have only been a registration event, with limited or no counselling administered. In most cases, we would expect to see more counselling occur beginning at the second visit.

A simple cross-tabulation between reported number of visits from a CHW during pregnancy (< 2 visits or 2 or more visits) and intervention group showed that mothers in the SP+ group were significantly more likely to receive 2 or more visits from a CHW compared to those in the control group (72% vs. 60%; p < 0.01). This holds true when controlling for clustering and other
factors from the model in Table 4. When the GEE model is run with number of CHW visits as the dependent variable, study group remains a highly significant predictor of CHW visits, and all other predictors become insignificant. This suggests a strong co-linearity between study group and frequency of CHW visits.

In sum, we know that smartphone use was associated with more frequent household visits by CHWs, and more frequent visits by CHWs was associated with an increased likelihood of FBD. We can therefore infer that increased frequency of CHW visits is a mechanism through which the SP intervention resulted in higher FBD rates.

Discussion

This study evaluated the impact of a smartphone decision support application for CHWs on their female clients’ use of FBD, a known determinant of maternal and newborn survival [23,36,37]. Overall, the odds of FBD among women counselled by smartphone-assisted CHWs were two times greater than the odds among women living in control villages, even after accounting for other known predictors of FBD. To our knowledge, this is the first peer-reviewed study looking at the effect of smartphone support for CHWs on FBD. It is also the first mHealth intervention study in a low-income country to explore potential pathways of behavior change.

In another cell phone intervention trial (‘Wired Mothers’) in Zanzibar, Tanzania, pregnant women received health education and appointment reminders via unidirectional SMS (text) messages, as well as vouchers to be used for direct two-way communication with primary healthcare providers [23,36,37]. Authors found a significant increase in skilled delivery among urban but not rural women, which was attributed to limited mobile phone access and low receptiveness of the intervention in rural areas. In contrast to the Wired Mothers study, the SUSTAIN intervention was implemented exclusively in rural or periurban areas, and because the application was built as a job aid for CHWs, it did not require cell phone ownership by female clients. Taken together, results of the two studies suggest that alternative smartphone functionalities (i.e. job aids for CHWs as opposed to direct patient communication) may be particularly useful in remote settings, where poverty is highest and FBD rates tend to be lower than in urban areas [30].
Comparing Table 5 and Table 6 reveals that the SP+ had a more significant effect on FBD in Singida Rural. This may reflect the fact that in Iramba, women are more likely to deliver at a facility to begin with, due to the presence of a public district hospital and greater number of dispensaries, which strengthen its health facility landscape. In fact, Iramba district has a lower proportion of women in the “high risk” groups for several significant predictors of FBD (parity, previous delivery experience, distance to the nearest facility) compared to Singida Rural. Consequently, we may be seeing a “ceiling effect” for Iramba district (p = 0.3, Table 6). While the impact of SP+ in this district is statistically insignificant with the current sample size, the measured impact of the intervention may still be clinically and/or programmatically relevant.

Parity and previous FBD experience were the strongest predictors of delivery location. First time mothers had about the same odds of delivering in a health facility as multiparous women with previous FBD experience, which may reflect perceptions of higher obstetric risk among women who are pregnant for the first time. The odds of home delivery among multiparae who had never delivered at a facility were thirty-three times greater than the odds of home delivery among their multiparous peers with previous facility delivery experience. The effect of multiparity is consistent with previous research in Tanzania and elsewhere, reporting strong correlations between higher parity and increased tendency for home births [29,31]. This may be explained by the fact that women with more children tend to have a higher burden of household and childcare responsibilities and thus may find it difficult to leave home for childbirth [38,39]. Furthermore, if a woman has delivered safely at home in the past, her perceived risks associated with childbirth diminish, and preference for home birth may be higher [40]. In contrast, if a women’s first delivery occurs at a facility, she is much more likely to go back again for future obstetric care, especially if the experience was positive. These findings support previous recommendations to target safe motherhood interventions according to parity in rural Tanzania [27], and call attention to the critical influence of past delivery experiences on FBD.

ANC attendance has been documented as a predictor of FBD in many low-income settings [31,41,42]; findings from the present study confirm this relationship. Pairwise comparisons of women in three high-risk groups (Figure 2) revealed that the SP+ had the largest impact on first-time mothers with low ANC uptake, with 32% more women in the experimental group delivering at or on the way to a health facility. A difference of 15% was observed among multiparous women with previous FBD experience and low ANC uptake, and only 10% among
similarly classified women with no previous facility deliveries. Our findings suggest that SP+ may boost FBD even in the absence of high ANC uptake, particularly among first-time mothers. Smartphone counselling by CHWs may have less of an impact on multiparous women, particularly those who have never delivered at a health facility. Health-seeking behaviours of women who have survived home births without complication are likely the most difficult to influence, and thus traditional behavior change communication strategies, regardless of delivery mode, may not be effective in this cohort. Additional research is needed to test innovative approaches targeting women by parity and experience with the healthcare system.

Findings are in line with previous studies reporting correlations between FBD and the distance to the nearest health facility [43–45]. The fact that a higher proportion of women in control villages lived closer to a health facility may have diluted the measured impact of SP+ in this study. Interestingly however, while distance was a significant predictor of FBD, it was not among the most important factors influencing delivery location. Furthermore, distance from the nearest hospital was not a significant predictor in our model, as opposed to another recent study in Tanzania [31,46]. This may reflect the method used to capture distance – i.e. difference between GPS coordinates – an “as the crow flies” measure, which does not account for actual routes taken or mode of transport, and therefore time required for travel. Alternatively, it is possible that for women who have had several recent interactions with the healthcare system (i.e. those with high ANC uptake), distance is not an insurmountable obstacle because they have made the journey previously. The finding that ANC uptake modified the effect of distance on FBD supports this hypothesis. What this suggests is that women in this context are quite resourceful: if they have an intention and desire to access facility-based services, then they will find a way to get there, regardless of distance.

A recent cross-sectional survey in Tanzania found that FBD was significantly dependent on the quality of ANC services, suggesting that the better the care received during pregnancy, the more likely a woman is to utilize FBD services [46]. In the present study, women’s assessment of health facility quality was not a significant predictor of FBD, however researchers’ assessment of quality using an in-depth facility scorecard remained significant in the final model. This result may reflect differences in the way the two quality metrics were measured. Women’s assessments captured subjective experiences of care by tapping into patient/provider dynamics encountered during clinic interactions, while the scorecard captured more objective, “hard”
service availability indicators such as stock levels of specific drugs and supplies, staffing, and health facility infrastructure. It is also important to note that we only asked women to assess the quality of their nearest health facility, which in most cases was a lower level dispensary. Since many facility-utilizing participants actually by-passed the nearest dispensary to deliver at a hospital, perceived quality of the nearest hospital may be a more significant predictor of FBD. Further research is warranted to tease these factors apart.

Several known predictors of FBD (e.g. socioeconomic status and maternal education) were not significant and therefore dropped from the final model. This is likely because the women sampled had very similar wealth and education profiles. These effects may be evident in a larger, more diversified sample, or if the variables had been measured differently.

We did find significant differences in FBD uptake between the two study districts, which reflects dissimilarities in the respective health facility landscapes and may be linked to affordability of services. In Singida, there were 5 health facilities in total, and a privately run (fee for service) hospital, whereas in Iramba there were 9 facilities in total, including a government-run district hospital. Despite Tanzania’s user-fee exemption policy for maternal and child health services, the odds of FBD among women living in a district with a government-run hospital were nearly 14 times greater compared to women living within the catchment area of a private, fee-for service mission hospital. As others have noted, alternative strategies for financing maternal health services, such as subsidies for transport and private care, are necessary if FBD rates are to be improved [46].

In sum, while the mHealth intervention had a positive impact, there were a number of other individual, and health-systems factors that influenced women’s capacity to access and/or decision to utilize FBD. Many of these factors cannot be directly addressed by use of smartphones, which serves as a reminder that context must first be carefully considered in order to understand what can be addressed by mHealth strategies, and most importantly, what cannot. While mHealth is not a panacea, it can be seen as a health systems strengthening tool, a way to enhance implementation of interventions, and may also help to diminish the "silo" approach to service/program delivery [47]. Results suggest that mHealth tools for frontline health workers can be used to augment the delivery of existing evidence-based MNCH interventions, however
their potential will only be maximized if they are part of a broader, functional health system focused on equitable, and accessible high quality service delivery for all.

**Study Limitations & Strengths**

Study findings should be interpreted with caution, as measured associations do not imply causation, and the study had several limitations. First, because the evaluation was conducted in a “real world” programmatic context, it was not feasible to mask intervention allocation. CHWs in the study area often interact through various seminars and training opportunities, and those in the control group may have been demotivated when they did not receive a smartphone. Second, we did not capture data on all known FBD predictors. For example, other studies have shown associations between FBD and the presence of traditional birth attendants, tribe/ethnic group, and use of community health insurance and other village-dependent factors [31,47]. Lastly, the study may have been strengthened if a baseline comparison measure were available, or if clusters were matched using additional criteria other than population size. In spite of these potential improvements, we have no reason to believe that baseline FBD rates were different in SP+ villages compared to control villages, and this potential drawback was likely addressed during the randomization stage. The study was further strengthened by statistical adjustment for village-level effects. Another strength of the study was that women were enrolled postnatally. If consent had been sought prospectively during pregnancy, this may have influenced the nature of women’s interactions with CHWs. Obtaining consent retrospectively eliminated this potential bias.

**Conclusions**

Smartphone application use by CHWs appears to add value by motivating CHWs to make more frequent household visits, and may be efficacious as one component of intervention packages designed to increase uptake of safe FBD. Within the context of this study, indications are that smartphone-based support for CHWs achieved the highest impact when used during counselling with first-time mothers, and helped to boost FBD rates even among women with low ANC uptake. These positive indications provide a strong rationale for investing in further research to evaluate cost effectiveness, sustainability, and potential for scale-up.
References


Chapter 5 Manuscript #2

Motivation of community health workers participating in a mobile health program to improve maternal, newborn and child health in Rural Tanzania

The second manuscript presents both quantitative and qualitative findings related to CHW motivation. Specifically, I compared quantitative measures of job-satisfaction and perceived self-efficacy among CHWs in both study arms. In-depth interviews provided key insights to contextualize these findings. This manuscript answers research question # (3a) How does SP+ influence CHWs’ motivation and work experience? and (3b) Do job satisfaction and perceived self-efficacy differ among CHWs depending on SP+ use?

Where direct quotes are presented, I refer to participants with a unique code (e.g. ‘C25’ for CHWs, or ‘FGD3’ for focus group discussions). Participant codes are summarized and defined in Table 1, Appendix E.

Prior to writing this manuscript, I conducted a broad analysis of CHW transcripts, coding specifically for factors that either motivated or deterred CHWs from completing daily tasks, regardless of the tools used. This analysis fell outside the scope of this manuscript, however results are summarized in Appendix D. These findings will be incorporated into a separate manuscript at a later date.
Abstract

Background

In Tanzania, community health workers (CHWs) play a key role in offsetting the country’s critical shortage of human resources for health, however in the absence of formal remuneration maintaining CHW motivation is a challenge. The emerging field of mobile health (mHealth) offers some innovative and potentially powerful approaches to strengthen health system support for CHW and increase their effectiveness in achieving key health outcomes. Few studies have investigated the impacts of mHealth tools on CHW motivation.

Methods

Results are drawn from a larger cluster-randomized, community intervention trial in Singida, Tanzania. Sixteen CHW pairs were randomly allocated to the experimental group, and 16 pairs to the control group (total N = 64); group assignment was unmasked. CHWs in the experimental group were trained on a smartphone application designed to improve data management, patient tracking and referral, and delivery of key health messages to pregnant women and mothers. Using Likert-scale questionnaires, we explored: 1) changes in CHW job satisfaction and self-efficacy over a 6 month period (N = 59). We also conducted in-depth, semi-structured interviews with 30 CHW using smartphones to understand perceived benefits and challenges during program implementation.

Results

Data are mean ± standard deviation. Independent-samples t-tests showed that shortly after program implementation, mean job satisfaction scores were higher among CHWs in the experimental group (2.09 ± 0.25) compared to the control group (1.89 ± 0.31), t(59) = 2.718, p = 0.01, however these scores converged over time and no significant difference was observed 6 months later (p = 0.42). CHW self-efficacy remained high throughout the study period and did not differ significantly between groups. Qualitative findings point to a number of perceived benefits of smartphone use (improved data management, communication, decision-making support, emergency response, enhanced social status and credibility, and perceived health
system improvements among clients). Reported challenges included logistic and technical difficulties, and unexpected community perceptions regarding smartphones.

**Conclusions**

Smartphone-based tools for CHWs can improve job satisfaction in the short term, however the potential value added by smartphones may be amplified if provided alongside one or more other incentives. In an ideal scenario, the Government would first formally integrate CHWs into the healthcare system so that they are recognized and compensated independently of any technology-based interventions implemented by NGOs.
Introduction

Tanzania has a critical shortage and unequal distribution of human resources for health [1], which hampers progress towards achieving universal coverage of quality reproductive, maternal, newborn and child health (RMNCH) services. While healthcare financing has steadily increased over the last twenty years, effective implementation of maternal healthcare has been sporadic at best [2]. One way to help address this gap is to leverage existing human resources, including community health workers (CHWs) – a cadre of peer-elected volunteers trained to deliver basic medical services at the community level. While CHWs are not intended to replace highly skilled health care professionals, they can help to strengthen linkages between rural communities and the formal healthcare system [3]. Those with relevant knowledge, experience and skills play an integral role in improving RMNCH outcomes through mobilization of communities, promotion of healthy nutrition and care behaviours, management of childhood illnesses, and delivery of preventive health education and services [4–7].

While the numerous positive impacts of CHW programs on community health are well documented [4, 8], the sustainability of such programs varies widely and debate continues over the most effective strategies to incentivize, support and retain cadres of high functioning CHWs at scale [9–12]. In many countries, including Tanzania, CHWs work on a voluntary basis, and in the absence of formal financial incentives (so-called “extrinsic” motivators) [13], programs use a combination of other in-kind and/or non-monetary sources to motivate CHWs and minimize turnover. Studies in Tanzania have found that many CHWs are intrinsically motivated by altruism and the desire to serve their communities [13, 14], however research from a diverse range of settings has shown that without adequate training, sufficient remuneration or incentives, supportive supervision and logistical support, CHW motivation inevitably deteriorates over time [4, 15].

Job satisfaction and self-efficacy are two intrinsic factors that influence CHW motivation, which in turn affects retention and quality of service provision in low- and middle-income countries (LMICs) [4, 16]. Bandura’s Social Cognitive Theory defines self-efficacy as one’s belief in his or her capacity to execute behaviours necessary to produce specific performance outcomes [17]. Bandura posits that “the stronger the perceived SE, the higher the goals people set for themselves and the firmer their commitment to them” [18]. This concept is most often used in
health studies to understand individual patients’ health-seeking behaviours, however it may also influence health worker motivation and performance [16]. It can be reasoned that among CHWs, those with higher perceived SE, or confidence in their abilities to carry out job-related tasks, might be more motivated to deliver high quality counselling and services to their clients compared to peers with lower perceived SE. Few studies have explored whether and how various sources of support and motivation (e.g. job aids, training and supervision strategies) impact self-efficacy and job satisfaction among CHWs in LMICs.

One way to help support CHWs in resource-poor areas is by equipping them with innovative job aids including information and communication technologies (ICTs). Mobile phone-based applications have been developed specifically for frontline health workers to enable quick access to relevant health information, improve data collection and reporting, assist with patient diagnosis and referral, and improve patient counselling. These approaches are relatively new in LMICs, where mobile phone ownership has risen sharply over the past decade. While the evidence base for so-called mobile health (mHealth) strategies is growing, there are still many research gaps to be filled [19]. While several published studies have investigated CHW motivation in Tanzania [13, 14, 20], none have looked explicitly at whether and how mHealth approaches can be used to improve CHW motivation, job satisfaction and self-efficacy.

The objective of this mixed methods study was to investigate the experiences and motivation of CHWs participating in a community-based smartphone (SP) intervention in rural Tanzania. Specific aims were to a) understand the perceived benefits of the SP application, according to CHWs; b) document the key challenges encountered during project implementation; and c) understand whether job satisfaction and perceived self-efficacy differ among CHWs depending on SP application use. It was hypothesized that both job satisfaction and perceived self-efficacy would be higher among CHWs equipped with smartphone aids compared to CHWs using standard, paper-based protocols.

**Methods**

**Study Setting and Programmatic Context**

Tanzania has only 5.5 physicians, nurses, and midwives for every 10,000 people, and only 55% of the country’s health workforce practices in rural areas, where approximately 70% of the total
population resides [2]. Further, while great strides have been made in reducing under-5 mortality, progress in reducing maternal and neonatal deaths (those occurring in the first 28 days of life), has been comparatively slow [2]. Consequently, the RMNCH agenda has been prioritized in recent years, as evidenced by the Tanzania Ministry of Health & Social Welfare’s (MoHSW) National Road Map Strategic Plan to Accelerate Reduction of Maternal, Newborn and Child Deaths [21]. One of the operational targets of this plan was to have CHWs offering MNCH services in 75% of villages by 2015, a task that has largely been taken up and implemented by nongovernmental organizations (NGOs) operating throughout the country.

In an effort to standardize the duties and expectations of CHWs overseen by various NGOs, the MoHSW developed a community-based Integrated MNCH training program specifically for CHWs [22]. In this three-week curriculum, CHWs learn how to identify pre- and post-natal danger signs, and when to refer clients to health facilities. They are provided with paper-based register books, and photo flipbooks for use with clients during household visits at specific times throughout pregnancy and infancy. During these visits, CHWs provide counselling on topics like infant feeding and nutrition, the importance of attending ANC clinics, birth plan preparation, and safe facility-based delivery.

The Government of Tanzania is currently working to develop a more robust training program for a national cadre of community health workers to be fully integrated into the formal health system in years to come. Therefore studies reporting on the experiences of CHWs participating in the iMNCH program are timely, as lessons learned may inform the development of refinement of the more detailed curriculum.

This study was carried out within the context of a Canadian-funded project, Supporting Systems to Achieve Improved Nutrition, Maternal, Newborn and Child Health (SUSTAIN), implemented by World Vision in Singida Region, Tanzania. The smartphone intervention was employed and evaluated in two SUSTAIN project districts: Singida Rural and Iramba.

**The SUSTAIN smartphone application**

As part of the SUSTAIN project, World Vision collaborated with D-Tree International to develop a smartphone (SP) application for use by CHWs during household visits with pregnant women. The application was developed using CommCare, an open source platform designed
specifically for use by frontline health workers. The application was developed in accordance with national iMNCH program guidelines and was intended for use along with the ministry-developed photo flipbooks during household counselling sessions with clients. The application serves as a point-of-care tool, guiding CHWs through electronic protocols and directing them to specific health counselling topics and messages based on a woman’s gestational age and answers to diagnostic questions. In addition, the application assists with client registration and follow-up, recognition of danger signs during pregnancy and the postpartum period, referral of clients to health facilities, and data management and reporting.

**Intervention Allocation & Study Design**

This research was conducted as part of a cluster-randomized, controlled, mixed-methods evaluation study assessing the impact of the smartphone intervention (SP+) for CHWs on facility-based delivery [23]. Thirty-two smartphones were randomly allocated to 16 pairs of CHWs working at the village level. An additional 16 pairs of CHWs were randomly assigned to the control group (total N = 64). CHWs in both study groups were trained on the national iMNCH program from July – August 2013. Shortly thereafter, CHWs in the experimental group were trained to use the SP decision-making support application.

**Data collection**

Semi-structured, in-depth interviews were conducted with 30 CHWs from experimental villages, and 30 CHWs from control villages between 6 to 8 weeks following the smartphone training session. Quantitative surveys were repeated approximately 6 months later with the same CHWs to examine changes in job satisfaction and self-efficacy over time.

**Job satisfaction & self-efficacy instruments**

Two likert-scale surveys were developed to measure CHW job satisfaction and perceived self-efficacy for fulfilling job expectations. The former was adapted from the widely used Job Descriptive Index (JDI), initially developed by Smith, Kendall, and Hulin [24]. Relevant scales from the 2009 edition [25] were modified from “yes/no” questions to scalar questions in order to better capture variation in answers. After extensive pre-testing and careful adjustment of items
to reflect local interpretations in Swahili, we arrived at a 48–item scale covering three main aspects of CHW work: overall satisfaction, and satisfaction with day-to-day duties.

Similarly, an 18-item scale was developed to measure perceived self-efficacy for fulfilling job expectations. As a starting point, we referred to the “Community Health Worker Tool Kit” developed by Meister et al. [26], which includes a variation of the General Self-efficacy Scale (GSE), used previously in Tanzania. Items on this scale were modified to reflect the context and proposed study objectives prior to pre-testing. A trained interviewer administered both job satisfaction and self-efficacy scales during face-to-face interviews with CHWs. Through the pre-testing process we found that participants were more confident in their answers when response options were listed in front of them, so we created a cue card system whereby CHWs selected one of five cards to answer each item (e.g. “always”, “sometimes”, “never” etc.).

**Qualitative interview guide**

We collected qualitative data concurrently in order to triangulate survey findings and explore contextual factors not captured by survey methods [27]. The semi-structured interview guide included open-ended questions designed to elicit rich narratives regarding CHWs’ opinions and experiences implementing the iMNCH and mHealth programs. Questions were developed with reference to findings from existing literature on CHW motivation, and covered topics such as motivators and deterrents, use of job aids, training, relationship with NGO staff and clinical supervisors, engagement with and support from community members, and opinions regarding the value of CHW work.

Consent materials and interview guides were translated into Swahili by a team of local research assistants, then pre-tested with CHWs at a health centre outside of the study catchment area. Tools were modified where appropriate to suit local language, literacy levels, and cultural interpretations.

**Recruitment and data collection procedures**

CHWs were recruited through World Vision’s program enrolment records. Eligible study participants had to a) be working in one of the two project districts where the SP intervention was implemented; and b) have completed the MoHSW iMNCH training course for CHWs.
Participants could be male or female and of any age. A total of 64 CHWs initially working in target villages were invited to participate in the study; of these, 60 consented to participate.

A team of 4 research assistants, fluent in both English and Swahili, were trained to conduct interviews with CHWs. All team members had at least an undergraduate University degree, and prior research experience. Levels of experience with qualitative interviewing varied among team members, thus the lead author (KH) developed and led a 4-day training course on qualitative data collection techniques, which included one day of practice interviewing with CHWs from villages external to the study. Research assistants had the opportunity to ask questions throughout the process, allowing for critical appraisal of each other’s interviewing skills, and immediate feedback and coaching from the lead researcher. This process proved useful not only for skill building, but also for the development and refinement of the survey and interview guide.

Interviews were conducted in private offices at an event centre in Singida town. After the consent script was read aloud by the interviewer, CHWs provided written consent. Socio-demographic information was collected first, followed by the quantitative Likert surveys. The qualitative interview was conducted last as we did not want any emergent discussions to influence or bias participants’ answers to survey questions. All qualitative interviews were digitally recorded with the permission of participants.

As a quality control measure on formal data collection days, the first author was present for a random selection of interviews to observe data collection techniques and to take detailed notes capturing participant reactions, emotions and body language. Following each interview, KH led thorough debriefing meetings with interviewers to discuss emergent themes, and to ensure that appropriate interviewing techniques (probing, judging tone of voice etc.) were used.

**Data Analysis**

A simple scoring system was devised to quantify responses to Likert-style questions on job satisfaction and self-efficacy. For example, in one section of the job satisfaction survey, CHWs were asked how often various words or phrases could be used to describe their work. Items that followed included positive phrases (e.g. rewarding, useful, enjoyable etc.) and negative phrases (uninteresting, waste of time, undesirable). CHWs would select a cue card labelled with one of
the following responses: “always true”, “mostly true”, “sometimes true”, “never true” or “unsure”. For a positive item, “always true” a score of 3 was assigned and “never true” was assigned a score of 0; conversely, for negative items, these responses were assigned a score of 0 and 3, respectively. An overall composite score was calculated for each scale, for each CHW, by taking the average of all individual item scores (thus, a maximum score would be 3.0 for each scale).

All statistical analyses were completed using SPSS for MAC software, version 22.0. Independent-samples t-tests were run for each scale to ascertain any differences between CHWs in control versus experimental villages. Chronbach’s Alpha was calculated to measure internal consistency and determine the validity of the scales.

Analysis of qualitative data was conducted using directed content analysis [28]. Interview transcripts were coded using Nvivo for MAC software, version 10.2.1. Following the methodology outlined by Saldana [29] we adopted a two-staged coding approach. In the first coding cycle, a general framework was used to “chunk” data into sections according to broad, pre-determined topics, with reference to the interview guide and field notes captured during de-briefing meetings with interviewers. During this process, detailed analytic memos were used to summarize emergent themes, formulate hypotheses, and to highlight particularly rich narratives warranting further exploration [30]. The secondary coding cycle involved the use of more specific sub-codes to categorize participant statements into themes derived directly from the data [29].

As a quality assurance measure, we followed a multi-stage process of transcription and translation, with a different bi-lingual research assistant responsible for each step, as follows: 1) one RA transcribed recorded Swahili interviews verbatim; 2) a second RA translated Swahili transcripts into English; and 3) a third RA was responsible for cross-checking the data by listening to the original Swahili recording while reading along in English. Discrepancies were discussed and resolved as a team during weekly meetings led by KH.

**Ethical Considerations**

The Office of Research Ethics at the University of Toronto, Canada, the Tanzanian National Institute for Medical Research (NIMR) and the Tanzanian Commission for Science and
Technology (COSTECH) approved the research protocol, and COSTECH issued a research permit to KH to conduct primary data collection in Singida Region.

Results

CHW Characteristics

Background characteristics of the 60 CHWs interviewed are summarized in Table 1. Because we recruited existing CHWs working in village-level pairs, there was a balance between male and female participants. Age, experience, reported workload, and coverage area (measured as village population) varied between participants. Most CHWs received their initial training from one of three organizations. According to CHWs, the types of trainings, topics covered, and extent of follow-up and refresher training varied between organizations. CHW characteristics did not differ significantly between study groups.

Table 1. Background characteristics of community health worker respondents (N = 60)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Category</th>
<th>Mean (range)/%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td></td>
<td>45.7 (26-66)</td>
</tr>
<tr>
<td>Sex</td>
<td>Male</td>
<td>50.8</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>49.2</td>
</tr>
<tr>
<td>Highest level of Education</td>
<td>Primary</td>
<td>88.9</td>
</tr>
<tr>
<td>completed</td>
<td>Some Secondary</td>
<td>7.9</td>
</tr>
<tr>
<td></td>
<td>Senior Secondary or above</td>
<td>3.2</td>
</tr>
<tr>
<td>Initial training organization</td>
<td>World Vision</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>Tanganyika Christian Refugee</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>Service</td>
<td></td>
</tr>
<tr>
<td></td>
<td>UNICEF</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>8</td>
</tr>
<tr>
<td>Experience (y)</td>
<td></td>
<td>16.2 (1-26)</td>
</tr>
<tr>
<td>Reported workload</td>
<td>Daily (hours/day)</td>
<td>7.3 (2-12)</td>
</tr>
<tr>
<td></td>
<td>Weekly (days/week)</td>
<td>3.2 (1-6)</td>
</tr>
<tr>
<td>Coverage area</td>
<td>Village population</td>
<td>2812 (1251-8727)</td>
</tr>
</tbody>
</table>

Instrument validation

Scales measuring job satisfaction and self-efficacy had high levels of internal consistency (Cronbach's alphas > 0.85). Repeated measures of both (at T1 and T2) were strongly correlated (r = 0.34, p = 0.01; and r = 0.5, p = < 0.01, respectively), suggesting good repeatability of instruments.

CHW job-satisfaction & perceived self-efficacy
Independent-samples t-tests showed that shortly after program implementation, mean job satisfaction scores were higher among CHWs in the experimental group (2.09 ± 0.25) versus the control group (1.89 ± 0.31), t(59) = 2.718, p = 0.009, however these scores converged over time and no significant difference was observed after 6 months (p = 0.422). Self-efficacy increased over time in both groups, although not significantly. We found no significant differences in self-efficacy between study arms (Figure 1).

Figure 1: Mean job satisfaction and self-efficacy scores among CHWs in experimental and control groups at 2 months and 8 months post-intervention.
Qualitative findings

Underlying factors that minimize CHW motivation:

It is crucial to note up front that almost all CHWs in both study groups (85%) expressed strong opinions regarding the need for fair remuneration for their work\(^{43}\). Lack of financial incentives was by far the most salient deterrent of CHW motivation, followed by lack of transportation, which was discussed in 70% of the one-on-one interviews. While many CHWs (40%) also acknowledged non-material (religious, moral, altruistic) motivations, the following perspective was common:

“In this area, I think things are changing and life has become so hard, so they [the Government and NGO staff] can’t expect us to waste all our time walking to reach the households for the whole week, without any payment. How do they expect us to earn the income to support our families? It’s a volunteer job I know that, but in reality there should be some support to help us live normal lives like other citizens.” [C39]

Self-efficacy and job satisfaction

Analysis of qualitative transcripts revealed that a majority of CHWs in both study groups had positive perceptions regarding their abilities to improve MNCH in their communities, which supports the quantitative self-efficacy findings above. Narratives suggest that CHWs generally interpret personal self-efficacy based on observed changes in client behaviours. CHWs expressed that they felt most confident in their abilities when they witnessed positive health behaviours in their communities (see Table 2 for select illustrative quotes). A portion of CHWs (~30%) discussed instances when behaviour change attempts had failed, which corresponded to feelings of defeat, and lowered self-efficacy. One CHW reflected on the case of a woman who delivered at home despite receiving visits at home:

\(^{43}\) Since the focus of this manuscript is on CHW motivation as it related to smartphone use specifically, a full analysis of CHWs’ perspectives on remuneration is out of scope. Narratives on this subject are rich and apply to all CHWs, regardless of study group, and therefore warrant in-depth discussion in a separate manuscript to be completed at a later date. A summary of these key findings, as well as other motivating factors are presented in Appendix D.
“When you have educated someone and they still endanger their life themselves, it’s as if the CHW hasn’t provided any education at all. It is a loss to the nation as well”. [C08]

Levels of CHW education and specialized MNCH training were closely linked to perceptions of self-efficacy. As one CHW articulated:

“I do my work very well, but I still need more education. You can see yourself that I get stuck sometimes when answering your questions, so I still need education […] especially on maternal health” [C21]

Given the role of education and training in forming self-perception, similarly high measures of self-efficacy in both groups may reflect the fact that CHWs received the same iMNCH training package at the beginning of the study.
Table 2. A selection of direct quotes related to perceived self-efficacy among CHWs

<table>
<thead>
<tr>
<th>Quote</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>“I like teaching because people pay attention to me and they tell me they understand very well… The other thing that encourages me is that they [clients and their families] are working on what I taught them to do, and this makes me love my job because I know that I’m understood.”</td>
<td>C10</td>
</tr>
<tr>
<td>“I'm prepared because after the [iMNCH] trainings we received, I went to educate my community and their number (in attendance) increased, that’s why I see the training is very important. When I had that training I became competent and now I know a lot of skills... so when I go to the village now my knowledge and skills are improved.”</td>
<td>C25</td>
</tr>
<tr>
<td>“When they listen to me by their own will this shows that they support me.”</td>
<td></td>
</tr>
<tr>
<td>“I am confident because I have been trained so I have to give the education to others</td>
<td>C45</td>
</tr>
<tr>
<td>“The trainings really helped us as CHWs to change our knowledge, and helped us to have more confidence when we go back to the community to provide health education, so we are happy because of that”</td>
<td>C17</td>
</tr>
<tr>
<td>“I have confidence in myself because when they ask questions about [maternal] health I am able to answer them well and that is why I was chosen as a CHW.”</td>
<td>C62</td>
</tr>
<tr>
<td>“My work is important because I am the first point of the healthcare system. I mean, without me doing the research at the village, even at the district level the planners would not get the data, because the community health worker is the one who lives among the people and she can recognize when women are pregnant, even the early pregnancies... and I can follow the child until it reaches the age of five years and send him to school, I mean really I am so important”</td>
<td>C02</td>
</tr>
<tr>
<td>“There was a time we received training on educating women to prepare nutritious porridge. We taught the community and we succeeded, because after that, all the small [undernourished] children increased their weight. I liked that very much because I educated the community, they understood me and they changed their practices”</td>
<td>C05</td>
</tr>
</tbody>
</table>

Job satisfaction

Qualitative findings drawn from in-depth interviews with CHWs in the experimental group (N = 30) help to contextualize the quantitative findings related to job satisfaction. The higher initial job satisfaction scores (T1) among CHWs using smartphones may be explained by a number of perceived benefits of the technology, summarized below.

Perceived benefits of the smartphone tool:
First, there were a number of indirect, or unintended benefits of smartphone support reported by CHWs. These included being able to call an ambulance when pregnant women went into labour or exhibited danger signs, calling clients ahead of time to schedule home visits with clients, and non-work related benefits such as the ability to communicate with friends and relatives, as noted by one CHW below:

“The device makes me happy, first of all because work performance becomes easy, and even to communicate with relatives - you get their [text] messages and lastly you can add praise [gospel] music to the phone and listen with your family” [C02]

The major benefits of smartphone use reported by CHWs are summarized in Table 3, and expanded upon with illustrative quotes below.

a. Improved data management and communication: “it simplifies my work”

A majority of CHWs in the SP+ group (87%) reported that smartphones simplified their work through improved communication, data collection and/or data management. As one CHW summarized:

“It helps most with the data collection. I mean it stores all the data and when I need information I can find it quickly in the phone. It helps me remember when I haven’t visited someone… It is not like those papers! You may find yourself forgetting with the papers but (with the phones) the information remains safe and the data travels to the places it needs to go.” [C49]

Six CHWs also attributed the phones to improved communication with NGO program staff, and one pointed out that this helped to curb favouritism by village leaders:

“I love it because it’s easy to get the news from far away. For example now when we are called to the (training) seminars we are invited on the phone, but many times in the past the invitation letters were lost along the way… the village chairperson would select someone else to go for training. Now with the phone there is no cheating! Village leaders can’t just send a relative or the person they are closest to.” [C50]
b. Decision making support: “You don’t have to disturb your head”

According to most CHWs (77%), smartphone-assisted client visits were shorter in duration than when paper-based protocols were used alone. When discussing how smartphones facilitated their work, CHWs reported less reliance on memory and increased confidence in counselling clients. As one CHW described:

“This phone helps a lot, especially with calculating the age of the mothers and their pregnancy. When you enter a date, it automatically gives you the (gestational) age, so you don’t have to disturb your head. It gives you good calculations.” [C51]

Another notable benefit of the application is its ability to systematically guide CHWs through counselling sessions. According to several participants, when mistakes are made, the smartphone “takes you back”, “shows you if you’re wrong” and “allows you to start fresh”:

“It directs me to information from the (photo) books, even the danger signs of pregnant women and children - you get them from the phone; let’s just say all the services you may need are there.” [C51]

One CHW illustrated the contrast between counselling with the phone versus counselling with the photo book alone:

“Ah the books - they just take you straight through... even if you are wrong somewhere, the books will not tell you. But the phone does, you see, so it helps. The phone helps me to register clients and reminds me about what time I should visit them. So the phone helps me more than the books did on their own.” [C25]

d. Enhanced social status and credibility: “people say that we have become wizards...”

About two thirds of the CHWs in both study groups reported being highly motivated by receiving recognition and respect of community members. Sixteen CHWs reported that use of the new technology with clients enhanced their social status, and/or improved clients’ trust in CHWs; several examples are illustrated below:
“The mothers, they were really surprised because this phone is different than
the ones that other people have. It really increases our popularity with them…
yeah, people say that we have become wizards with this new technology!” [C50]

“They are happy because of the work we do with the phone […] and they feel
free to tell us their secrets, even when you ask them their inner most secrets
they tell us.” [C51]

Some CHWs also believed that the smartphones increased their perceived legitimacy within the
health system:

“The women are so happy about this phone because when I use it they know they
are not being played… previously when we would call them to meetings they
would listen to us talking and they say that we (CHWs) are just politicians, that
we were just talking and that nothing will actually be implemented. But now they
understand and believe in what we are doing because they see me using the
phone.” [C43]

e. Client Benefits: Perceived health system improvements - “they feel they have a certain value
now”

The majority of CHWs (90%) reported that overall, clients were happy with the smartphone-
based services. According to CHWs, most of their clients associated smartphone use with health
system improvements, and as a signal of shifts toward improved transparency, accountability
and patient-centred care. As one CHW described:

“They are happy because their information is taken down correctly. Now
women are satisfied because the phone takes their information and sends it
quickly, like when you go to visit a mother you talk with her and you send it
directly. It’s not like the past where you had to wait until the end of the
month to send her information to the dispensary.” [C21]

As another CHW explained, some clients interpreted smartphones as a sign that the government
was taking their health issues more seriously:
“They’re happy with this tool because when you go to provide education, they feel good to be registered on the phone, and they feel good to be given explanations and advice... They just feel more appreciated; it’s like they feel they have a certain value now”. [C51]

Another CHW shared similar feedback:

“My clients, they feel good to see the changes happening. Many admire (the phone) and say ‘Oh, they care about our health! They must care, that’s why the community health workers have been given job aids’… unlike in the past. When we carried a lot of papers, they felt sorry for us and asked us, ‘are you not tired of carrying all these books?’” [C49]

Positive perceptions appeared to extend beyond individual female clients. The same CHW reported that many in the broader community took note and positively responded to the phones:

“The phone is very helpful; even the community feels so good when I tell them that the phone will transfer the information they provide. So I can say the phone has simplified my job, and the community has seen the importance... they say these are changes that make them feel like the services are improving.” [C49]

Positive community responses were also mentioned as a benefit by six other CHWs in the study.

**Reported challenges with smartphone use by CHWs**

While the experiences described by CHWs using smartphones were overwhelmingly positive, several notable challenges emerged during the initial project implementation phase. The main obstacles reported by CHWs were technical or logistical in nature, or related to misunderstandings by clients and community members.

*a. Charging, distance and lack of transport*
CHWs encountered a number of logistical, security, and technical challenges with the technology. Almost all CHWs (90%) reported frustrations with charging the phones, particularly in the first few months after training:

“The one thing that I don’t love about the phone is the issue of charging. Sometimes it switches off even before I enter the client’s name! This is embarrassing for me. When this happens it’s the end of the work!” [C25]

Lack of electricity in the villages was a common problem, and many CHWs had to travel long distances to access electricity at charging kiosks or health facilities. Most CHWs found this to be the greatest challenge, and articulated feelings of frustration:

“It is the issue of charging the phone. When I have to travel a long distance to find a place for charging, it’s a problem. If we could have a place to charge the phone nearby it would be much better. Then we may charge the phone at any time. Sometimes people call me when they need me and they cannot reach me on the phone… sometimes the shop is closed where we go to charge. It’s all because of power”. [C32]

While many CHWs believed that patient counselling sessions were shorter and more efficient when the smartphone application was used, one participant rightfully noted that, ultimately, the work burden remained the same because of underlying distance and transportation challenges:

“I mean the phone has not changed the distance from one household to another. If I spent twenty minutes (with a client) before I had the phone, I still use the same amount of time now… so the phones have not changed the distance at all - we still need some means of transport.” [C39]

Most CHWs claimed that when they encountered challenges with the phones (i.e. charging, lack of electricity, technical problems) they continued to make household visits with clients. In these cases, CHWs would use paper-based methods to deliver counselling and record client information, and then enter the data into the phone application later, once the problem was resolved.

b. Negative perceptions among clients and communities
On the community side, unforeseen consequences of the smartphone intervention included confusion regarding CHW roles and volunteer status, perceived inequities, and misunderstandings regarding the purpose and intention of smartphone use by CHWs. According to CHWs, some clients initially had negative perceptions of the smartphones. For example, when one CHW began making household visits with the smartphone, some women did not understand why she was typing on her phones during counselling sessions:

“At first when they didn’t know much about the phones, they thought we were doing other things while talking with them…they’d say “you are just writing to other people and wasting my time… I have other things to do, I’m leaving”. But now they have started to understand us. We have given them education, and when they see their names, children and date in the phone, then they understand.” [C45]

Another challenge encountered by two CHWs from different districts was the belief that smartphones were associated with freemasonry. As described elsewhere, in Tanzania the Freemasons are “believed to be a secretive society of men who have the power to manipulate and control others with their wealth” [31].

“A bad thing about my job was when I first started using this phone, some people prohibited me from entering their information into the phone. They said that it is a freemason’s phone and some even insulted me… I felt so bad in this situation. When I visited one woman to register her in the phone she refused to admit she was pregnant – instead she insisted she had stomach tumours. She also started to cry because she thought that I was a Freemason member.” [C42]

“When I was providing the services with the phone, I asked her to give me her phone number, and she replied, “what is the phone number for”? I explained the purpose but she said she was afraid to give the phone number because she thought I would use it to register her with the freemasons.” [C35]

These CHWs explained that beliefs about freemasons usually arise after a sudden increase in one’s wealth or material possessions in these communities. So on the one hand, smartphone use
was thought to increase CHWs’ perceived social status among some community members, and participants saw this as a benefit and positive outcome of the project. On the other hand, in some instances smartphones created the illusion of increased wealth, which not only led to suspicions regarding freemasonry, but also to misperceptions regarding CHW remuneration. One CHW articulated this problem:

“They are happy about the phone but they ask us who gave it to us and I tell them, it is our sponsors (World Vision). What I fear is that because we are visiting them now, they think we are paid. I tell them I am not paid and we are just working (as volunteers). But they think we are employed! Nowadays they tell us to give gifts to their babies, but I tell them I don’t have any gifts, I am just registering them with the phone… but these are minor things, I think they will come to an end over time.” [C49]

As another CHW suggested, introducing a new technology to the village may actually amplify perceived inequities and can lead to security risks for CHWs:

“You know there are no phones like these in the street, so when they see that you have it they ask, ‘where did you get it?’ and ‘how much did it cost?’ and so on. So they are following you, now that is very dangerous! I had to stop bringing my phone to the charging kiosk because there was a man who asked me about it and he followed me there three times. He wanted me to sell it to him and said I should go and buy another one but I told him I can’t, it’s for my work.” [C51]

Concerns regarding risk of phone theft were mentioned by 4 CHWs. One CHW highlighted the need for NGO staff to address this risk more seriously:

“About this phone, the organization should really think of us, like giving us solar battery chargers to keep at home\(^4\) so that they won’t be stolen (at the charging kiosk). If the

\(^4\) The project acquired one solar charger for each village, to be used (and therefore shared) by both CHWs in a given village.
phones are stolen it will be a big loss for the community and even those who have given the phones to us”. [C21]

Discussion

This study investigated whether a smartphone-based tool for volunteer CHWs participating in a community-based MNCH program improved their job satisfaction and perceived self-efficacy for fulfilling job expectations, two key drivers of health worker motivation. Quantitative measures and qualitative indications converge to show how perceived self-efficacy remained relatively high over time in both study groups. In contrast, quantitative measures of job satisfaction were significantly higher among CHWs in the intervention group. To explore the reasons for this result, qualitative offer a nuanced illustration of how positive perceptions of smartphone use might contribute to CHWs’ job satisfaction. Overall, CHWs reported that smartphones simplified their tasks, and were widely accepted and valued by a majority of their clients. While higher job satisfaction may have incentivized CHWs initially, it was clear that a lack of formal compensation was an on-going challenge for CHWs in both study groups. It is likely that despite the initial peak in job satisfaction, the underlying challenges encountered by CHWs in this context (e.g. heavy workload, competing household tasks, lack of transportation and financial incentives) outweighed any perceived benefits of the job aid over time.

This apparent “novelty effect” has been reported elsewhere [19] and raises valid concerns regarding the sustainability of such interventions. However, as noted by others – novelty effects may be mitigated by “leveraging good user-centred design, engagement strategies and providing feedback to the users on their performance” [19]. These approaches were incorporated into the SUSTAIN project to some degree, by NGO staff and partners. For example, D-Tree conducted extensive field-testing with CHWs and modified the MNCH application in an iterative process whereby feedback regarding user preferences was continually discussed and the application modified accordingly. The smartphones allowed CHWs to communicate directly with staff, which enabled real-time technical support. Monthly or bi-monthly face-to-face meetings with CHWs also allowed World Vision field staff to provide supportive supervision and feedback, and deal with any logistical concerns that emerged. It should be noted that similar novelty effects might occur not only among CHWs, but also among NGO program staff, and CHW
clients, the intended beneficiaries; this possibility should be considered and monitored over the course of any community-based mHealth initiative.

Many of the reported advantages of smartphone use are consistent with other mHealth studies in developing countries. For example, use of Commcare (and similar applications) by frontline health workers has reportedly led to lowered workload, improvements in time management and efficiency, heightened social status and/or recognition, and streamlined data collection processes [19, 32]. A recent observational study from India suggests that CommCare use by CHWs can positively impact the quality and experience of care provided [33]. Whether use of phone-based job aids influences health worker self-efficacy has been less frequently explored; to date, only one other published project measured self-efficacy of midwives using cell phones [34]. These authors found that midwives’ use of cell phones for communication purposes was associated with improved access to peer information resources (i.e. direct communication with other midwives), which in turn was associated with higher self-efficacy.

Community recognition has been documented as a critical motivator for CHWs in many settings, [14, 35–37] and may contribute to retention and turnover rates. Narratives describing perceived boosts in social status and credibility in the experimental group are consistent with findings of other research reporting improved credibility of frontline health workers due to SP-based tools [38]. According to participant narratives, use of smartphones during household visits were thought to increase CHWs’ perceived social value, as some clients reportedly treated them with more respect and considered the phones to be indicative of CHW status.

Research in various contexts has found that in addition to formal recognition and compensation, CHWs may be motivated by a number of other intrinsic factors including altruism [13, 14]. Material incentives range from uniforms, bicycles and supplies to money for transportation and provision of awards and certificates [36, 39–42]. While cell phones may serve as a short-term incentive for CHWs, another study in Uganda found that CHWs actually preferred an incentive package comprised of a T-shirt, badge, and bicycle, to a mobile phone [40]. Taken with our findings, this serves as a reminder that CHWs’ preferred incentives might differ from what donors and implementers believe to be effective or potentially useful. Stakeholders within the global health community emphasize the potential of technology and innovation, however our
findings suggest that long-term job satisfaction among CHWs may be achieved by provision of other tools and incentives first.

Based on CHW narratives, the introduction of SP technology in this remote, low-income setting seemed to have important impacts on community members’ perceptions, not only of CHW status and credibility, but the state of the broader health system as well. As some CHWs described, the SPs, for the most part, signalled positive changes within the health system, and by extension, clients associated SPs with increases in government accountability. While WV did collaborate with district-level health teams, the SUSTAIN project was not a government initiative, and the SPs were provided by WV. Of critical importance here is that if technology symbolizes improvements in the health system, then programs must work to ensure that these expectations are actually met. It would be unethical not to, as false expectations of the health system could increase service uptake in the short term, but threaten repeat utilization over time if services are unsatisfactory.

As with any public health intervention, the possibility of unintended consequences is always a risk. While on the one hand, providing CHWs with smartphones may increase their social status and credibility, potentially improving community trust and confidence in them, we must also be mindful of potential negative consequences including security risks, and misperceptions among their clients. Formative research prior to project implementation should be used to answer the following critical questions: a) could this intervention create or widen any existing inequity gaps? If community members view the SPs as emblematic of wealth, power, or status, is it possible that they might become envious of CHWs, and if so, how might their relationships with CHWs be impacted? Findings point to the critical importance of involving entire communities from the beginning of any ICT intervention – for example, through community seminars, to clearly explain the intention and specific functions of the SPs, and emphasize the need for these tools to support CHW job-related activities. This should help to address any community uncertainties and potentially negative consequences for CHWs.

**Study limitations and future directions**

In this study we captured cross-sectional measures of job satisfaction at two time points approximately 6 months apart among 60 CHWs participating in an existing NGO program. We
might expect to see different results if a larger number sample of CHWs were followed up for a longer period of time. Results should be considered with the following stipulations in mind:

First, it was initially hypothesized that use of smartphone-based electronic protocols might increase CHWs’ confidence in their abilities to complete job-related tasks, however reported self-efficacy was high in both study groups and did not change significantly over the course of the intervention period. This may reflect that fact that self-efficacy was high to begin with in both groups (a ‘ceiling effect’); therefore it would be difficult to detect any significant increases with a limited sample size. Additionally, even with a larger sample size, moderate yet statistically significant differences may not be interpreted as practically or programmatically significant.

Second, well-designed likert scales are a useful method of quantifying latent constructs such as participant attitudes, which are not easy to observe directly. Despite their utility, likert scales are vulnerable to three sources of bias: central tendency bias (avoidance of extreme response categories), social desirability bias, and acquiescence bias (when participants tend to agree with statements as they are articulated by the interviewer) [43, 44]. We attempted to minimize potential bias by ensuring a balance of positively and negatively phrased questions, and by carrying out a thorough instrument piloting and refinement process.

Third, given the programmatic context, it was impossible to ensure masked allocation of the SP intervention – several CHWs in the control group were aware that CHWs in other villages had received smartphones as part of a pilot project. This may partially explain why some CHWs in the control group had lower job satisfaction scores initially. To this end, we did not capture baseline (i.e. pre-intervention) measures of self-efficacy and job satisfaction, which would have provided a more nuanced picture of how SUSTAIN interventions influenced each group over time.

Fourth, participant answers may have been influenced by social desirability bias – that is, the tendency to answer in a way that presents oneself in a positive light. Since individuals tend to give more socially desirable answers during face-to-face interviews than in self-administered, anonymous surveys [45], future studies might consider collecting this data through anonymous electronic surveys administered via mobile phones. Leveraging available mobile phone
technology to monitor CHW self-efficacy more regularly may have a positive impact on CHW morale, in and of itself. This approach may also lower the supervisory burdens for field staff and clinical supervisors.

A final consideration is that over time, CHWs trained on SPs are at risk of becoming overly dependent on the electronic protocols, and if/when SPs are not available for use (due to damage, lack of charge, theft etc.), self-efficacy may drop as a result. Future implementation research might investigate whether CHWs remain confident with the material/health content without use of the smartphone support. To ensure this does not occur, it is critical for organizations and programs to provide periodic training and re-training sessions, whether SPs are being used or not.

**Conclusion**

Findings suggest that smartphone-based tools for CHWs can improve job satisfaction in the short term, however the potential value added by smartphones may be amplified if provided alongside one or more other incentives. In an ideal scenario, the Government would first formally integrate CHWs into the healthcare system so that they are recognized and compensated independently of any technology-based interventions implemented by NGOs. Further investigation is required to elucidate causal links between CHW job satisfaction, performance and ultimately, MNCH outcomes.
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Chapter 6 Manuscript #3

“It makes you someone who changes with the times”: Perspectives on a smartphone-based counselling application for rural Tanzanian health workers.

The third manuscript presents both quantitative and qualitative findings regarding perceived CHW performance and quality of care among clients and supervisors. Cross-sectional assessments of CHW services were compared between study groups; and analysis of focus group and interview transcripts was conducted to explore key survey results in greater depth. This manuscript answers research question #4: How does SP+ influence perceived quality of care among CHWs’ supervisors and female clients? This manuscript has been prepared for submission to the peer-reviewed journal, *Human Resources for Health*. 
Abstract

Introduction

Mobile health (mHealth) applications have been developed for frontline community health workers (CHWs) to help simplify their tasks, enhance service delivery, and promote healthy behavior change, particularly surrounding pregnancy and childbirth. These strategies hold promise, however to be effective and sustainable, they must be designed and implemented with the patient perspective in mind. Few studies in low-income countries have examined how mHealth approaches influence clients and supervisors’ perceptions of CHW performance and quality of care.

Methods

This study was conducted within the context of a larger cluster-randomized, community intervention trial implemented by World Vision in Singida, Tanzania. Sixteen pairs of community health workers were randomly allocated to the experimental group, and 16 pairs to the control group (total N = 64). CHWs in the experimental group were trained on a smartphone application designed to improve data management, patient tracking, and delivery of key health messages to pregnant women and mothers. Using Likert-scale questionnaires, we compared cross-sectional measures of CHW performance and quality of care as assessed by 14 CHW supervisors and a randomly selected sample of female clients (N = 572). Fourteen semi-structured interviews with clinic-based supervisors and 12 focus group discussions with women clients generated qualitative findings to contextualize survey results.

Results

Compared to the control group, CHWs using smartphones scored significantly higher on quality of care assessments by female clients 10 months post-intervention. Qualitative interviews revealed that women’s perceived benefits of smartphone-based counselling fell into four categories: 1) increased quality of care; 2) improved communication; 3) improved efficiency and data management; and 4) modernity, credibility, and up-to-date knowledge. For clients, these benefits were linked to perceived improvements in the overall quality of the health system.

Conclusions
In general, the smartphone application was acceptable and valued by supervisors and women clients. Reported benefits of the intervention related to both prescribed and non-prescribed uses of the phone, such as improved communication, improved health system efficiencies, and better data reporting and management. Phones were also thought to signify modern, up-to-date biomedical information, which is highly desirable during pregnancy and childbirth in this context.
Introduction

Community health workers (CHWs) are widely acknowledged for their potential to drive improvements in maternal, newborn and child health (MNCH), particularly in countries where major shortages in human resources for health persist [1, 2]. In resource-constrained settings, CHWs can play a key role in improving MNCH by linking women and their families to the formal health system through community engagement, home visits, referral and follow-up. This link is especially critical in rural areas, where ensuring access to high quality services may be hampered by weak public health infrastructure.

Research shows that well-supported CHW programs can lead to improvements in MNCH service delivery, positive behaviour change, and decreased morbidity and mortality rates [1-3]. However, studies also caution that without adequate program resources, focused tasks, and proper investments in supportive supervision and training, the quality and effectiveness of CHW services may be limited. Expectations of CHWs to perform complex tasks without adequate organizational and technical support further limit the potential of CHW programmes [3, 4].

Tanzania has seen substantial progress in terms of child survival in the past decade, however advances in maternal and newborn survival, and family planning have been much slower [5]. The Tanzania Ministry of Health and Social Welfare (MoHSW) has prioritized MNCH and acknowledges the key role of CHWs, as demonstrated by the release of national integrated MNCH guidelines and training materials for CHW [6]. Despite this, village-level CHW remain unsalaried volunteers, elected by their communities, with a majority trained and managed by various non-governmental organizations (NGOs) across the country. The lack of formal remuneration is an ongoing challenge in Tanzania [7], however other research suggests that non-monetary incentives, including supplies, work tools and job aids, may help to motivate and retain CHWs [8].

One recent strategy to support CHWs is through the use of mobile health (mHealth) technologies, which may help to simplify CHW tasks and improve the quality of care offered to their clients. Projects using mobile devices to enhance health service delivery have proliferated in recent years, and CHWs are increasingly targeted as end users [3, 9]. For example, low-cost mobile phone applications can be used by CHW as a point-of-care tool to streamline data collection, and assist with decision-making, diagnosis and treatment of patients. These
approaches have generated a great deal of enthusiasm among international organizations,
governments and industry stakeholders, however programmatic evidence to inform
implementation and scale-up is currently insufficient [10]. Furthermore, few studies have
critically examined the use of mobile technologies for healthcare in low and middle-income
countries (LMIC) [11]. Consequently, social scientists have called for a more critical
perspective “to analyze the social, cultural and political dimensions of health and medical apps
around the world”[3].

The failure to scale up mHealth beyond pilot projects may be partly attributed to mismatches
between how designers and end-users engage with their social worlds [12], and misconceptions
of how the use of digital technologies affects intended target groups [11]. In addition to calls for
more robust effectiveness, efficacy, and cost-effectiveness studies [9, 10], the evidence for
mHealth approaches in low-income countries also lacks rich ethnographic data on various
stakeholder perspectives. For mHealth strategies to be effective and sustainable, they must be
accepted not only by technology users (frontline CHW in this case) but also by intended
beneficiaries. If the ultimate goal of mHealth approaches is to improve population health
outcomes, then strategies to promote healthy behavior change must be designed and
implemented with the patient perspective in mind.

The aim of this mixed methods study was to a) explore both positive and negative perceptions of
facility-based supervisors and female clients regarding a smartphone-based job aid for CHWs;
and b) investigate the impact of smartphone-assisted counselling on perceived quality of care in
rural Tanzania. Study findings are intended to inform the design and implementation of future
mHealth projects intended to support frontline health workers working to improve MNCH.

Methods

Study Setting

This study was carried out within the context of a larger community-based project, Supporting
Systems to Achieve Improved Nutrition, Maternal, Newborn and Child Health (SUSTAIN),
implemented by World Vision in Singida, central Tanzania. The smartphone intervention was
implemented and evaluated in a community intervention trial, described elsewhere [13], in two
districts, Singida Rural and Iramba. Singida is one of the poorest regions in Tanzania;
approximately 49% of households live below the poverty line [14]. Access to health services is also a challenge, as the region has only 158 health facilities for a total population of 1.4 million people [15]. A majority of households in these districts belong to one of two ethnic groups: Nyiramba and Nyaturu, and most families rely on crop and livestock production as their primary livelihood source.

**The smartphone intervention (SP+)**

As part of the SUSTAIN project, World Vision collaborated with D-Tree International to develop a smartphone application for use by CHWs during household visits with pregnant women and mothers. The application was developed using the open source platform, CommCare. The application was developed in accordance with national integrated MNCH program guidelines and was intended for use along with the ministry-developed photo flipbooks during household counselling sessions (SP+). The application serves as a point-of-care tool, guiding CHWs through electronic protocols and directing them to specific health messages and counselling topics in the photo books, based on a woman’s gestational age and answers to diagnostic questions. In addition, the application assists with client registration and follow-up, recognition of prenatal and obstetric danger signs, referral of clients to health facilities, and data management and reporting. SPs were intended to enhance face-to-face interactions between CHWs and their clients rather than replace them completely. This distinction is critical because in Tanzania, communication is socially embedded, and people tend to trust context-rich, in-person communication more then distant, technology-based communication [16].

**Data collection**

Findings were derived from several sources: a) semi-structured interviews (SSI) with CHW supervisors (facility-level nurses/midwives); b) household surveys with women clients; and c) focus group discussions (FGDs) with clients. We collected data in both intervention (SP+) and control villages over a 9-month period from October 2013 - July 2014.

Two likert-scale surveys were developed for supervisors and women clients to produce composite scores on CHW performance. The client survey included 14 items capturing women’s opinions regarding CHW knowledge and competencies in MNCH, the quality of CHW relationships with clients and their families, and overall satisfaction with CHW services.
The 22-item scale for supervisors covered similar topics, plus several items on supervisory observations (e.g. quality of reporting, rapport with clients). For each item, participants selected a cue card labeled with one of the following responses: “strongly agree”, “agree”, “disagree”, “strongly disagree” or “unsure”. To minimize the potential for acquiescence bias, we ensured a balance of positively and negatively phrased questions [17]. Surveys were administered in person by a Swahili-speaking interviewer.

Qualitative SSI and FGD guides were designed to capture more nuanced contextual information related to the above topics. An additional section, specific to CHW use of smartphones, was included for FGDs and interviews in SP+ villages. SSI and FGD guides included open-ended questions designed to elicit rich narratives regarding client and supervisor experiences and interactions with CHW.

All study tools were developed in English, with key inputs from Tanzanian colleagues with expertise in MNCH. After translation into Kiswahili, the tools were pre-tested extensively with women and clinic staff external to the study, and modified to ensure comprehensibility, relevance, and cultural appropriateness.

Women clients were eligible to participate if they were: a) between the ages of 16 – 49 years; b) pregnant during the intervention period; d) and visited at least once by a CHW during this period. All supervisors working at a facility in study catchment areas were eligible to participate.

Previous research on women’s reproductive experiences in rural Tanzania found that the presence of Caucasian North American-based researchers attracted onlookers, thereby compromising privacy and influencing participant responses [18]. So as to avoid compromising privacy and the responses of participants, the first author focused her efforts on training a team of experienced research assistants to collect data for this study. An experienced team of research assistants, fluent in both English and Swahili, was trained to conduct all SSIs and FGDs after completion of a 3-day qualitative research methods seminar. Following each SSI or FGD, KH led thorough debriefing meetings with interviewers and facilitators to discuss emergent themes, draw comparisons, and to ensure that appropriate interviewing techniques (probing, judging tone of voice etc.) were employed.
All interviews and FGDs were digitally recorded with the permission of participants. SSIs with supervisors (N = 14) occurred approximately 3 months after SP+ implementation. During the same period, we conducted initial FGDs with a randomly selected sub-sample of pregnant women in 2 control villages and 2 experimental villages in each of the two study districts (8 FGDs in total). In consultation with World Vision field staff, we purposefully selected “best case scenario” villages where CHW appeared to be highly active, making regular visits to pregnant clients, and submitting timely reports to SUSTAIN staff and supervisors. This enabled us to document experiences of women clients in areas where both paper-based and electronic counselling protocols were working well. This is analogous to the ‘positive deviance approach’ whereby researchers identify “innovative strategies from 'positive deviants' in health care, those organizations that consistently demonstrate exceptionally high performance in an area of interest” [19].

Follow up FGDs were conducted 9 months post-intervention with 4 of the 8 groups of women to validate findings and document any changes in perceptions/opinions over time. Household surveys with women were conducted 9 months post-intervention. Sampling and recruitment are described in detail elsewhere [13]. SSIs with supervisors were conducted in private rooms at health facilities and each lasted approximately one hour. FGDs with clients were conducted in private, central meeting locations, accessible by all participants (e.g. at a church, school, or village office) and each lasted between two to three hours.

By drawing from a combination of quantitative and qualitative data collected from several informant groups, we aimed to capture varying perspectives while achieving triangulation of methods and sources. This strategy tends to enhance the reliability and credibility of study findings [20].

**Data Analysis**

A simple composite score was calculated based on client and supervisor responses to likert-scale questions. For a positive item, “strongly agree” was assigned a score of 3 and “strongly disagree” was assigned a score of 0; conversely, for negative items, these responses were assigned a score of 0 and 3, respectively. An overall composite score was calculated for each scale, for each participant, by taking the average of all individual item scores. Independent-
samples t-tests were run for each scale to ascertain differences in client assessments of CHW in control versus SP+ villages. Chronbach’s Alpha was calculated to measure internal consistency and determine the validity of the scales. All statistical analyses were completed using SPSS for MAC software, version 22.0.

To ensure high quality transcripts, we followed a multi-stage process of transcription and translation, with a different bi-lingual research assistant responsible for each step, as follows: 1) one research assistant (RA) transcribed digitally recorded Swahili interviews verbatim; 2) a second RA translated Swahili transcripts into English; and 3) a third RA was responsible for cross-checking the data by listening to the original Swahili recording while reading along in English. Discrepancies were discussed and resolved as a team during weekly meetings.

Analysis of qualitative data was conducted using conventional content analysis [21]. Interview transcripts were coded using Nvivo for MAC software, version 10.2.1. Following the methodology outlined by Saldana [22] we adopted a two-staged coding approach. In the first coding cycle, a general framework was used to “chunk” data into sections according to broad, pre-determined topics outlined in SSI and FGD guides. During this process, detailed analytic memos were used to summarize emergent themes, formulate hypotheses and to highlight particularly rich narratives warranting further exploration [23]. The secondary coding cycle involved the use of more specific sub-codes to categorize participant statements into themes derived directly from the data [22].

**Ethical Oversight**

The Office of Research Ethics at the University of Toronto, Canada, the Tanzanian National Institute for Medical Research (NIMR) and the Tanzanian Commission for Science and Technology (COSTECH) approved the research protocol. The study adhered to standard ethics guidelines and best practices with respect to informed consent, confidentiality, and participant anonymity. All research team members (including data collectors) completed the National Institutes of Health online training course, *Introduction to the Responsible Conduct of Research.*
Results

Quantitative Results

A total of 56 women participated in FGDs. Twenty-seven % (N =15) of participants were pregnant with their first child at the time of the FGD. Demographic characteristics of participants are summarized in Table 1.

Table 1. Demographic Characteristics of Focus Group participants

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Mean (range) / N(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>28.4 (16-49)</td>
</tr>
<tr>
<td>Parity</td>
<td>2.8 (0-8)</td>
</tr>
<tr>
<td>Number of pregnancies</td>
<td>4.0 (1-10)</td>
</tr>
<tr>
<td>Education</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>9 (16.1)</td>
</tr>
<tr>
<td>Primary</td>
<td>44 (78.5)</td>
</tr>
<tr>
<td>Secondary</td>
<td>3 (5.4)</td>
</tr>
<tr>
<td>Religion</td>
<td></td>
</tr>
<tr>
<td>Christian</td>
<td>32 (57.1)</td>
</tr>
<tr>
<td>Muslim</td>
<td>24 (42.9)</td>
</tr>
</tbody>
</table>

Fourteen supervisors (all nurses or nurse-midwives) completed in-depth interviews and quantitative assessments of 63 CHWs. Both experience in their current role and experience working with CHW varied widely (Table 2). All supervisors worked full-time, and most (N=11) were stationed in village-level dispensaries. Almost all claimed they conducted monthly supervisory meetings with CHWs, however most noted that this was not a high priority due to a heavy workload and lack of time.

Table 2. Demographic Characteristics of CHW Supervisors

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Mean (range)/N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Years of experience in current position</td>
<td>20.4 (1.5-37)</td>
</tr>
<tr>
<td>Months of experience supervising CHW</td>
<td>28.1 (1-108)</td>
</tr>
<tr>
<td>Number of CHW currently supervising</td>
<td>5.5 (2-14)</td>
</tr>
<tr>
<td>Facility Type</td>
<td></td>
</tr>
<tr>
<td>Hospital</td>
<td>2</td>
</tr>
<tr>
<td>Dispensary</td>
<td>12</td>
</tr>
</tbody>
</table>

Scales measuring CHW performance had high levels of internal consistency (Cronbach's alphas > 0.85). CHW in the SP+ group scored moderately higher on assessments by both supervisors.
and female clients after 10 months, however only the latter performance metric was statistically significant (Table 3).

Table 3. CHW assessment scores by supervisors and clients, expressed as mean (SD)

<table>
<thead>
<tr>
<th>Scale</th>
<th>SP+</th>
<th>Control</th>
<th>P-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHW performance, assessed by supervisors</td>
<td>2.28 (0.43)</td>
<td>2.15 (0.48)</td>
<td>0.27</td>
</tr>
<tr>
<td>(N = 63)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHW quality of care, assessed by clients</td>
<td>2.02 (0.34)</td>
<td>1.95 (0.40)</td>
<td>0.05</td>
</tr>
<tr>
<td>(N = 572)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*independent-samples t-test

In general, both supervisors and clients spoke very highly of CHWs, regardless of which study group they belonged to, and most participants in both groups advocated for further recognition and improved support for CHWs. When supervisors were asked to rate the performance of each CHW, the majority “agreed” or “strongly agreed” with the statements “I believe he/she should be paid a salary”, and “Overall, I am satisfied with this health worker’s performance” (88% and 92%, respectively). These assessments did not differ significantly between study groups.

When clients were asked to rate the quality of care provided by CHWs, a majority agreed or strongly agreed with the statement, “Overall, I am satisfied with the care provided to my family by community health workers” (92% of women in SP+ villages vs. 87% in control; p = 0.05). On the topic of maternal health, 89% of women in SP+ villages and 84% of women in control villages agreed or strongly agreed with the statement, “CHWs know a lot about the health of mothers” (p = 0.01).

Qualitative findings

Qualitative analyses were conducted to explore potential explanations for quantitative results above in more depth. In particular, we focused on the transcripts of FGDs with women in SP+ villages to explore the reasons why CHWs with smartphones may have scored higher by clients, on average, on measures of perceived quality of care. Key themes to emerge from this analysis and illustrative direct quotes from participants are summarized in Table 4 to Table 7 below.
SP+ counselling to support learning

Different opinions emerged from FGDs regarding the utility of the SP+ for learning. In some instances, women were misinformed about how the phone was used by CHWs. For example, one participant perceived that the phone prompted CHWs with specific maternal health information, when in reality the tool directs CHWs to relevant topics in the photo books (which are used by CHWs in both study groups) [quote 1, Table 4]. In contrast, several women in another FGD pointed out that learning cannot be attributed to the phone, per se – rather, it is the CHW who ultimately does the teaching [quote 2, Table 4].

In most FGDs (75%), participants agreed that CHWs’ use of the photo book tool during counselling sessions was the key to knowledge transfer because of the practical examples it provided; a salient example of this perception is illustrated in quote 3, Table 4. According to a majority of women in SP+ villages, the main benefit of the smartphone is its point of care decision-making support (“it’s a tool for guidance”), and its ability to remind CHWs about what they say and do during home visits (“the phone becomes like a memory”). This perception was common among both clients and supervisors, and is illustrated in quotes 4 and 5 in Table 4.
Table 4. Participant perceptions on smartphone-assisted counselling and client learning

<table>
<thead>
<tr>
<th>#</th>
<th>Quote</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>“The phone helps them to teach us about danger signs, the things that we didn’t know about. Like bleeding - we didn’t know, swelling of the face we did not know it. The phone is writing the things that you don’t know.”</td>
<td>FGD4</td>
</tr>
<tr>
<td>2</td>
<td>“They don’t help us learn because the phones can’t speak… I mean it helps us by sending the information, but [knowledge] about the health of the mother and child - it’s the CHW who teaches and explains to us, not the phones.”</td>
<td>FGD7</td>
</tr>
<tr>
<td>3</td>
<td>“They use the photo book for teaching. They show you a picture and give you explanations, maybe on nutrition for pregnant mothers… she shows you those foods in the picture, maybe there is vegetables, beans and whatever, you just look at the picture and she says that you should wash them first and then continue to use them. She shows you on the photo book, you see, therefore the lesson becomes more familiar because you see everything practically.”</td>
<td>FGD1B</td>
</tr>
<tr>
<td>4</td>
<td>“I think the phone is better, because she might have many things on her mind so it won’t be easy for her to remember everything she needs from the book, but with the phone she will search and all the information will come at once.”</td>
<td>FGD7</td>
</tr>
<tr>
<td>5</td>
<td>“The quality of counselling has increased because earlier, the CHWs asked questions just by using their own mind… but now they ask questions according to the guidance they’ve been given.”</td>
<td>FS9</td>
</tr>
</tbody>
</table>

A major benefit reported by clients was increased efficiency during emergency situations due to improved communication, and the ability to call for transportation, in particular [quotes 1-2, Table 5]. A few women also observed improvements in communication between CHWs and health facility staff. One client reflected on her own experience to illustrate how phones can be used by CHW remotely to assist with the referral process, and to help rectify problems encountered at clinics. Drawing on her own lived experience, she shared her personal story [quote 3, Table 5].

Another communication-related benefit mentioned by women in three FGDs was that CHWs could schedule household visits in advance [quote 4, Table 5]. This is an important benefit of the phones because previously, CHWs would often show up unannounced, and if clients were away, the opportunity for counselling sessions would be lost. Lastly, the phones provided a private communication channel between CHWs and clients, which strengthened their rapport and enabled women to continue engaging with the health system despite negative interactions.
with facility-based clinicians. Quote #5 is a striking illustration of the importance of CHW/client relationships, and the potential ways in which mobile technologies can help to strengthen them.

Table 5. Participant perceptions on smartphone-assisted counselling and improved communication

<table>
<thead>
<tr>
<th>#</th>
<th>Quote</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>“Now our problems can be solved quickly, like when a patient has a bad condition the CHW can call the ambulance at the regional hospital, they come to pick you up, and your life will be saved, yes that’s the good thing about the phone.”</td>
<td>FGD3</td>
</tr>
<tr>
<td>2</td>
<td>“I think the phone is good as you will have easy communication. For example when you were in a serious condition in the past you had to send a child to find the health worker and it took too much time for the child to cross the river, but nowadays, you just call her and she will be there to help you, so it saves time.”</td>
<td>FGD7</td>
</tr>
<tr>
<td>3</td>
<td>“The phone is better [than paper-based tools] because it simplifies things… For example, after I delivered this baby, the baby became very sick, and when I went to the dispensary there was some confusion… I have seen that my information can reach the required place easily because my CHW talked with the nurse and sent her the [SMS] message. I read it, it was telling the nurse to give me a referral card to go to the regional hospital if the required service is not possible at the dispensary, so that’s why I can say the phone is better.”</td>
<td>FGD1B</td>
</tr>
<tr>
<td>4</td>
<td>“The phone helps you communicate with them, so even when they come to visit you, they inform you through the phone that they will be coming to visit” (FGD4).</td>
<td>FGD3</td>
</tr>
<tr>
<td>5</td>
<td>“I think the phone is good because, for example, if you are mistreated by nurses at the clinic, you can go and explain to the CHW, and she will tell you what you need to know using the phone [via SMS], without the workers at the hospital knowing that she has communicated with you.”</td>
<td>FGD3</td>
</tr>
</tbody>
</table>

Improved efficiency and data management

Both supervisors and clients linked SP use to increased efficiencies at various levels of the health system. A few supervisors observed that smartphones led to greater efficiencies in healthcare delivery at the community level by enabling CHW to visit and register more women, as illustrated by one supervisor in quote #1, Table 6. This particular supervisor was responsible for CHW from both control and SP+ villages, and thus was able to assess differences in the quality of reporting [quote 2, Table 6]. Another nurse in Iramba district had a similar observation, stating that CHWs with phones “send their information directly, and keep their records well”. Supervisors and clients also reported that registration of women with phones led
to a more streamlined process once they arrived at the facility, as illustrated in quotes 3 and 4, Table 6. Some clients reported that smartphone-assisted registration and data collection at the household level led to shorter visits [quote 5, Table 6], which was widely regarded as a positive change.

Women also observed that their information could be more easily retrieved from a phone than from traditional paper-based registries, as highlighted in quote 6 [Table 6]. In addition, clients emphasized the importance of reporting data in a timely manner, which could be facilitated by smartphones [quote 7, Table 6]. The ability of the phone to keep track of client data was widely regarded as a benefit. Women appreciated that they did not have to repeat any personal information during subsequent visits because the information could be easily retrieved from the phone [quote 8, Table 6]. A particularly helpful function of the phone, as mentioned by women in two FGDs, was that it could remind clients of expected delivery dates [quote 9].

According to some FGD participants, smartphone use by CHWs, and the resulting efficiencies outlined above were thought to be indicative of improvements in the overall health system.

*Modernity, credibility, and up-to-date knowledge*

Across FGDs in both study groups, women participants expressed a shared value of, and demand for, novel, up-to-date information. One particularly astute participant observed that up-to-date knowledge is critical because maternal and child health recommendations are subject to change over time [quote 1, Table 7]. The phones were seen as a timely way for CHWs to receive invitations to health seminars and training, an important source of up-to-date information on community health [quotes 1-3, Table 7]. One of the supervisors echoed this opinion, stating her belief that the smartphone tool could at least partly compensate for gaps in CHW training and skills by quickly directing them to relevant, up-to-date information [quote 4, Table 7].
Table 6. Participant perceptions on smartphone-assisted counselling: improved efficiency and data management

<table>
<thead>
<tr>
<th>#</th>
<th>Quote</th>
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<tbody>
<tr>
<td>1</td>
<td>“You may find that those with phones have registered sixty clients but those with no phones have not reached that number… maybe he or she has only registered twenty or thirty clients.”</td>
<td>FS2</td>
</tr>
<tr>
<td>2</td>
<td>“The CHWs using phones have improved their reporting more than CHWs who don’t have phones. Their data are somehow longer, but those who have no phones - their data are short [less detailed].”</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>“When they register a mother, they type her name, her sub-village, her village chairman, date of birth, and gestational age, and so now registration is simple… and when they come to the dispensary, they tell us that they have been registered in the phone so it’s easy for us here.”</td>
<td>Nurse, Singida Rural</td>
</tr>
<tr>
<td>4</td>
<td>“For me I think it’s good because [the phones] help to send our information to the health facility easily… when she visits you at home, the health facility will also know your information, so when you go there, they already know what your problem is.”</td>
<td>FGD3</td>
</tr>
<tr>
<td>5</td>
<td>“I think the time is less now compared to the past. She can now do two things at the same time, I mean now she can take your information records in the phone and send them directly, and after a short while she gets the feedback [on what to do/ask next] so it saves a lot of time.”</td>
<td>FGD3</td>
</tr>
<tr>
<td>6</td>
<td>“With the phone she will just search and find what she needs without using a lot of energy… [with the books] it’s a waste of time, but with the phone it’s very fast to search.”</td>
<td>FGD 7</td>
</tr>
<tr>
<td>7</td>
<td>“The phone simplifies because they can get information quickly when they want to help us, because they store the information in the phone and we see that our data can easily be sent to the required place compared to papers, which can be delayed.”</td>
<td>FGD1B</td>
</tr>
<tr>
<td>8</td>
<td>“It’s good because he records all the information in the phone… even the other day I did not tell him anything [from before], and he could remember ‘oh you told me about this and that’ - all the information is there”</td>
<td>FGD4</td>
</tr>
<tr>
<td>9</td>
<td>“The phone is good because sometimes pregnant women forget their due dates, so they may stay at home until delivery comes. If this happens the CHW may find the child is dead or something bad has happened so I think [the phone] is very important.”</td>
<td>FGD4</td>
</tr>
<tr>
<td>10</td>
<td>“With the phones things are going more professional now, so you will never be told to come back [to a health facility] another week to collect your feedback. No, you will be given the answers instantly so we think the quality is much better now.”</td>
<td>FGD3</td>
</tr>
</tbody>
</table>
Table 7. Participant perceptions on smartphone-assisted counselling: modernity, credibility and up-to-date knowledge

<table>
<thead>
<tr>
<th>#</th>
<th>Quote</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>“As time goes on generations can be stubborn, so they need more education… It’s because of globalization, as you see us here we are all different ages, and even they [the CHWs] are different ages, and the children who are born now are born in a different environment than us. Those who were educated in the past are different from people educated it in the current moment, so when the CHWs go for seminars and come back they gain new things and we get new motivation… and if you have forgotten anything they remind you.”</td>
<td>FGD3</td>
</tr>
<tr>
<td>2</td>
<td>“For me I see the good thing about using the mobile phone is that it helps them to understand issues quickly. For example, to know if there is a seminar… because of the phone, a CHW can know when there is a seminar about nutrition or anything else, he will find out early and he will get the knowledge for us.”</td>
<td>FGD4</td>
</tr>
<tr>
<td>3</td>
<td>“When she [the CHW] wants to help me she will find the information recorded there, even if she is incapable of helping me [herself], it becomes easy with the phone.”</td>
<td>FGD1B</td>
</tr>
<tr>
<td>4</td>
<td>“The phone is very important because it makes your activities simpler and ensures that you are up-to-date. It makes you someone who changes with the times.”</td>
<td>FS11</td>
</tr>
<tr>
<td>4</td>
<td>“I think it’s good that she records your issues in the phone… she may send your information and get replies, so she can immediately tell you what is going on so I feel good about that.”</td>
<td>FGD1</td>
</tr>
</tbody>
</table>

The application’s automated prompts (referred to by women as “replies”) signified expert medical advice and guidance. For some clients, the phone’s prompts seemed to validate the protocol used by CHWs during counselling sessions [quote 4, Table 7]. In general, the automated responses were considered an important benefit of the phone because women perceived that CHWs received relevant health information more quickly. Furthermore, the health information provided was perceived to be trustworthy because women assumed it was coming from a source of authority.

Confusion regarding the information sources and data transfer processes

It is important to note that while most perceptions of SP+ were positive, as outlined above, and while most clients had a basic understanding of how the application operates, a few FGD participants claimed they had never been counselled with a SP, or did not remember it being used during household visits. Several others noticed the SP but assumed it was the CHW’s own personal device. Some participants made statements like “I see she has a phone, but I don’t...”
know how she uses it” [FGD 1]. Several women believed that the SPs were good because they “send the information to where it needs to go… to the right place” [FGD3], however they were uncertain as to whether data was sent to CHWs from a computer or from another person on the other end.

**Discussion**

Findings suggest that smartphones can be a persuasive tool, as they shape women’s views of frontline health workers, the health information they deliver, and even perspectives of the broader health system. In general, use of smartphones by CHWs was well accepted by women in their communities, and considered a welcomed health systems addition by both supervisors and clients. Participants reported improvements in communication, data management, referral, and the quality and reliability of health information. Many of these findings validate information provided by CHWs in this study, which is detailed elsewhere [7]. Findings also illustrate what other social scientists have noted – that mHealth innovations “entail more than just the introduction of new technologies; they result in new relationships, expectations, and responsibilities” [12].

**Technology and authoritative MNCH knowledge**

Women’s emphasis on, and demand for ‘modern’ and ‘up-to-date’ MNCH information reflects an increasingly medicalized maternal health environment in Tanzania [24]. With respect to pregnancy and childbirth, our findings support research from other settings [25-29] suggesting that biomedicine has become a dominant (i.e. authoritative) knowledge system in this study context. This likely reflects the presence of World Vision and other NGOs in the region who have conducted various outreach activities aimed at increasing women’s demand for health facility-based maternity services. What this study suggests is that the smartphone application is viewed as a powerful vehicle for timely access to this information, vis-à-vis CHWs. In this study, many women assumed that the application’s systematic prompts were sent from an authoritative medical source – a clinician, usually – which led some clients to believe that messages delivered by CHWs were more legitimate, up-to-date, and trustworthy. Since biomedicine is increasingly driven by science and technology [30], it is not surprising that CHW use of SPs becomes entangled with perceptions of modernity, expertise, and improvements in the overall health system. Instant provision of systematic, time-specific messages, and
immediate collection and transfer of patient data, appears to improve credibility of health counselling in this context.

Perceptions of SPs and authoritative knowledge have important implications for maternal health-seeking behaviour, particularly in the rural Tanzanian context, where service utilization is low. First, if women’s confidence and trust in the system can be boosted by new, technological modes of health promotion, then they may be more likely to utilize available services (e.g. antenatal and obstetric care) at health facilities. However, it is well established that increasing women’s demand for services is insufficient if the necessary services are not available, not appropriate, or too expensive for women to access [31, 32]. While electronic methods of health promotion may improve women’s perceptions of the health system, there is also some risk that women may defer to trusting this expertise, rather than questioning the advice or seeking clarification/elaboration when appropriate. As Davis-Floyd and Sargent articulate in their study in the United States, women increasingly rely on biomedical authority during pregnancy, not merely because the source of information is a health authority; rather, women may “acquiesce to biomedical authority when it is backed by the power of technology” (p.127) [33]. Similarly, in their study of antenatal care among American women, Browner and Press argue that “technology designates certain kinds of knowledge as ‘authoritative’ and in doing so helps drive medicalization processes” (p. 142) [25]. These studies investigated pregnancy in the United States, and focused on more invasive, diagnostic medical technologies such as ultrasound; however, our data suggest that SPs used by frontline health workers may elicit similar responses among women in rural Tanzania. Further studies are required to test this hypothesis more explicitly.

FGDs revealed that some women did not understand how the smartphone application works, and many were uncertain of the source of the phones “replies”. Another study in India found that frontline health workers used mobile devices as a “tool for soft intimidation” of clients and their families (p. 4) [34]. These researchers found that health workers would purposely avoid clarifying clients’ misperceptions about how the device worked. For example, some women (wrongfully) believed their conversations with health workers were being recorded and sent to medical authorities or Western researchers, and health workers would avoid correcting them in a non-malicious effort to promote healthy behaviour change. While these strategies are well intended and may help achieve intervention goals, it is critical that the functionality of mHealth
tools is properly explained to intended beneficiaries so that women can make informed decisions regarding their health. Further research on the relationship between mHealth technology, authoritative knowledge, and how these factors influence actual health seeking behaviours during pregnancy and childbirth, is warranted.

Non-prescribed benefits of the SP intervention

The SP application was specifically designed to improve the quality of health counselling during pregnancy through enhanced diagnostics, decision-making and referral by CHWs. It is important to note however, that some of the most important benefits of the SPs were actually non-prescribed functions [34] – for example, using phones to call for transportation during emergencies, to schedule household visits in advance, and to follow up with women clients via SMS. Communication was also important for facility-based supervisors, as CHWs could send information about specific patients, or monthly summary reports via SMS. As part of the SUSTAIN project, World Vision covered the costs of airtime for data syncing only (about 5000 TZS per user, per month). If CHWs chose to use the device for communication-related purposes, they were expected to pay for these costs out of pocket, as this was outside the scope of the intervention.

CHWs’ extended use of primary SP functions beyond the data collection and counselling application resonates with findings in another study of CommCare use by frontline health workers in India [34]. According to these authors, non-prescribed use of devices may further advance project objectives by increasing health worker availability to clients; our results agree with this finding. We also observed that smartphones strengthened existing relationships by opening up new lines of private communication, independent of clinicians. In some cases SPs enabled CHW to follow-up with clients and continue to provide health education despite negative health facility experiences, which enhanced CHWs’ relationships with clients. These findings suggest that SP support for CHWs may further strengthen relationships by facilitating more meaningful and longer-term engagement with communities, which is crucial, given the relatively short duration of most mHealth project funding cycles to date. While CHWs in the SUSTAIN study were allowed to keep the smartphones at the end the project, there is no longer any structure in place to monitor their activity, provide feedback, or cover costs associated with
airtime and maintenance of the smartphones. Consequently, critical questions regarding sustainability remain.

Women’s emphasis on communication as a key benefit of the smartphones raises several important questions to be considered by future programmers and policy makers. First, who should be responsible for covering airtime costs for communication, for how long, and by what means? If these costs are not budgeted into program costs, then such interventions may place an added financial burden on CHWs, especially if both clients and supervisors now expect to receive regular phone calls and SMS messages. This is particularly problematic in Tanzania, where CHWs currently work on a voluntary basis, with no official financial remuneration.

Second, questions related to equity of access must be grappled with, as SP-facilitated communication may only benefit women who have access to a mobile phone. While mobile phone ownership has skyrocketed in recent years – at least 63% of households in Mainland Tanzania now have access to a mobile phone [35], and ownership among poor households increased from 5 to 39 percent between 2007 and 2012 [36] – a majority of women in Singida did not personally own a mobile phone at the time of the study. Further, if a family does have access to a mobile phone, women in the household may not use it regularly if it is owned by a male family member [37, 38]. This consideration is especially important in rural Tanzania, where mobile phone ownership tends to be higher among men compared to women [39]. Implementers of mHealth projects must be cognizant of the potential imbalance in client experiences due to inequities in access among intended beneficiaries.

**Study Limitations**

Qualitative findings were drawn from analysis of a small number of FGDs and interviews, and are therefore not intended to be representative of women or clinicians outside of this particular sub-sample of study participants. Further, varying levels of interaction with CHWs at the time of the study limited our analysis of supervisor perspectives. Most supervisors claimed they were too busy to engage with CHWs on a regular basis, thus their opinions of the SP+ intervention were more neutral, and their reflections less nuanced compared to those of clients.
Conclusion

This study demonstrated that in general, a SP application designed to assist CHWs with client registration, counselling and referral, was acceptable and valued by supervisors and women clients. Reported benefits of the intervention related to both prescribed and non-prescribed uses of the mobile phone, such as improved communication, improved health system efficiencies, and better data reporting and management. Phones were also thought to signify modern, up-to-date biomedical information, which is highly desirable during pregnancy and childbirth in this context. Given that mHealth tools can potentially modify community perceptions of health system services, intended beneficiaries’ expectations may also be influenced, thus it is imperative to critically assess issues of sustainability beyond the funding cycle of time-limited projects. This is particularly critical in contexts where CHWs work on a voluntary basis as mHealth tools are unlikely to substitute regular financial incentives.
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Chapter 7 Manuscript #4

Keeping secrets in the cloud: mobile phones, data security and privacy within the context of reproduction in Tanzania

The fourth manuscript presents a qualitative analysis of participant perspectives (CHWs and their clients) on smartphone use, data privacy and confidentiality. I did not plan to investigate this subject at the outset of the study; therefore it is not explicitly outlined in the research questions or aims in Chapter 3. However, the issue of secrecy surrounding pregnancy and childbirth emerged as a consistent and salient theme during discussions regarding uptake of maternal health services. Consequently, I felt it was important to explore these perceptions with respect to the SP+ intervention. This chapter is relevant to question #5: What are the barriers and facilitators of maternal health services use, and to what extent can they be addressed by CHWs and SP+? This manuscript has been prepared for submission to the peer-reviewed journal, Reproductive Health Matters.
Abstract

A growing body of evidence points to the potential value of mobile phone-based technologies in helping to improve community health systems in low- and middle-income countries. However, these ‘mHealth’ approaches also carry considerable risks with respect to data security, individual privacy, and confidentiality. This qualitative study was conducted within the context of a mobile phone-based intervention to improve women’s uptake of maternal health services in rural Tanzania. The paper examines the perspectives of frontline community health workers and their female clients regarding data security and privacy within the context of pregnancy and childbirth. Study findings demonstrate that the use of new technologies to capture health data can have both positive and negative impacts on perceptions of personal privacy and confidentiality. Women’s concerns regarding privacy were strongly related to the belief that pregnancies and expected delivery dates must be kept secret. This reflects the perception that pregnancy renders women vulnerable to witchcraft imposed by jealous neighbours. Women also shared concerns that health workers’ male partners could access their private information. Strong community engagement to understand household gender dynamics and community perceptions of ICTs prior to intervention development is recommended.
Introduction

As global connectivity continues to expand, so too does the use of mobile technologies in health and development initiatives worldwide. As a result, the relatively new fields of ‘ICT4D’ (Information and Communication Technologies for Development), ‘eHealth’ (electronic health) and ‘mHealth’ (mobile health) have gained considerable momentum in recent years. The increasing availability and affordability of mobile phones in low- and middle-income countries presents unprecedented opportunities to collect and analyze health-related data, and to facilitate widespread dissemination of health information and knowledge. By beginning to bridge the digital divide, low cost mobile technologies have potential to help strengthen health systems in the poorest regions of the world, which may contribute to improvements in global health equity (1).

Despite the growing body of evidence demonstrating the value of mHealth solutions in low- and middle-income countries (LMICs) (2-5), these approaches also carry considerable risks with respect to data security, individual privacy and confidentiality. In a 2011 report, the World Health Organization highlighted citizen data security as one of the top barriers to scaling up mHealth in LMICs, calling for the development and implementation of appropriate strategies and policies to protect individuals’ right to privacy (6). In addition, a consortium of international development organizations recently developed ‘The Principles for Digital Development’, a set of guidelines that encourage integration of established best practices into any technology-based development programs (7). Principle 8 is to “address privacy and security”, which entails assessing risks to users and their data, and developing risk mitigation plans as appropriate. The Principles are “living guidelines […] intended to serve as guidance rather than edict, and to be updated and refined over time” (7). While the Principles have been endorsed by a number of leading global health organizations including UNICEF and the World Health Organization, it is unclear whether and how privacy and security guidelines are operationalized in practice.

According to an impact evaluation of mHealth regulation in Africa (8), many countries in the region have no comprehensive data protection legislation in place, highlighting the need to prioritize data security by mHealth programmers, implementers and researchers. The report notes that in places where privacy and data protection measures are in place, they are often not specific to the healthcare sector and instead are embedded within broader privacy and data
protection legislation (8). Tanzania is one country where, to date, there are no specific laws to
guide the use and disclosure of health and medical data in general (9), and no explicit privacy
policy related to mHealth. Tanzania’s current national eHealth strategy does highlight the
importance of prioritizing individual data protection, with one of its “strategic principles” being
to “guarantee patient information right, integrity and confidentiality in line with emerging public
health access needs” (p.9) (10). However, it does not outline any concrete procedures for doing
so, leaving room for interpretation and potentially loose application of patient privacy principles
by implementers.

Research on the privacy and security implications of eHealth and mHealth initiatives in high-
income countries has proliferated recently (for recent reviews see 11, 12), but we have been
unable to identify any published studies from low- and middle-income countries. Several recent
reviews of mHealth approaches in LMICs make reference to the importance of data security and
patient confidentiality in principle, but none investigate whether and how best practices are
actually interpreted and/or applied across contexts. There is a paucity of research to examine the
views of technology users (e.g. frontline health workers) or intended beneficiaries (e.g. CHW
clients) regarding the privacy impacts of mHealth.

Results presented here aim to help close this knowledge gap by exploring user and beneficiary
perceptions of data security and privacy within the context of a smartphone intervention to
improve women’s uptake of maternal health services in rural Tanzania. It should be noted from
the outset that the authors did not set out to investigate this subject explicitly. Rather, data
security and confidentiality emerged as important themes during the analysis stage of a broader
study on CHW and client perceptions of smartphone-based counselling and data collection (13-
15).

Methods

Study Setting

This study was carried out within the context of a larger community-based project, Supporting
Systems to Achieve Improved Nutrition, Maternal, Newborn and Child Health (SUSTAIN),
implemented by World Vision in Singida Region, central Tanzania. The smartphone
intervention was implemented and evaluated in a community intervention trial (cite main
outcome paper), in two districts, Singida Rural and Iramba. Singida Region is one of the poorest regions in Tanzania; approximately 49% of households live below the poverty line (16). Access to health services is also a challenge, as the region has only 158 health facilities for a total population of 1.4 million people (17).

*The smartphone intervention (SP+)*

As part of the SUSTAIN project, World Vision collaborated with D-Tree International to develop a smartphone application for use by CHWs during household visits with pregnant women and mothers. The application was developed using the open source CommCare platform, in accordance with national integrated MNCH program guidelines. This tool was intended for use along with the ministry-developed photo flipbooks during household counselling sessions. The application serves as a point-of-care tool, guiding CHWs through electronic protocols and directing them to specific health messages and counselling topics in the photo books, based on a woman’s gestational age and answers to diagnostic questions. In addition, the application assists with client registration and follow-up, recognition of prenatal and obstetric danger signs, referral of clients to health facilities, and data management and reporting. World Vision Tanzania began deployment of the application in Singida in 2013, by providing smartphone devices and training and supportive supervision to CHWs within the context of a program aimed at delivering a package of MNCH interventions through community mobilizers, CHW and improved health facilities serving 324 villages. The study was designed to measure any key impacts of this novel intervention through a cluster-randomized approach to this rollout.

*Data collection*

We collected data in both intervention (SP+) and control villages over a 9-month period from October 2013 - July 2014. Findings presented here were drawn from two sources: 1) in-depth interviews with 60 CHWs (30 from SP+ villages and 30 from control villages); and b) focus group discussions (FGDs) with a sub-sample of their female clients (N=56).
Interview and FGD guides were designed to capture detailed information related to women’s relationships with CHWs and how these relationships are shaped by both modes of MNCH counselling and support (SP+ versus paper-based protocols only). An additional section, specific to CHWs’ use of smartphones, was included for FGDs and interviews in SP+ villages. Interview and FGD guides included open-ended questions designed to elicit rich narratives regarding interactions between CHWs and their clients. All study tools were developed in English, with key inputs from Tanzanian colleagues with expertise in MNCH. After translation into Kiswahili, the tools were pre-tested with women and clinic staff external to the study but with similar socio-demographic profiles as the study population. Scripts were modified to ensure comprehensibility, relevance, and cultural appropriateness.

A small field research team recruited CHWs through World Vision’s program enrolment records; we invited 32 CHWs from each arm of the study to participate in semi-structured, in-depth interviews. Eligible CHW study participants (a) worked in one of the two project districts where SP+ was implemented; and (b) had successfully (?) completed the national ‘Integrated Maternal, Newborn and Child Health’ training course for CHWs. Participants could be male or female and of any age. Eligible women participants were (a) between the ages of 16 – 49 years; (b) a client of a CHW enrolled in the study; and (c) pregnant at the time of recruitment. Women were recruited through clinic or CHW register lists; we invited 6-8 randomly selected women from each list to participate in FGDs.

A team of 6 research assistants, fluent in both English and Swahili, was trained to conduct interviews and FGDs after completion of a 4-day qualitative research methods seminar. Following each interview or FGD, KH led “deep-dive” debriefing meetings with interviewers and FGD facilitators to discuss emergent themes, draw comparisons, and to ensure that appropriate interviewing techniques (probing, interpreting participants’ tone of voice, etc.) were employed.

We conducted initial FGDs with a randomly selected sub-sample of pregnant women in 2 control villages and 2 experimental villages in each of the two study districts (8 FGDs in total). In consultation with World Vision field staff, we purposefully selected “best case scenario” villages where program monitoring records indicated CHWs were highly active, making regular visits to pregnant clients, and submitting timely reports to SUSTAIN staff and supervisors. This
enabled us to document experiences of women clients in areas where both paper-based and electronic counselling protocols were apparently being delivered as intended. To validate findings and document any changes in perceptions/opinions over time, the same team of researchers conducted follow up FGDs with 4 of the 8 groups of women at 9 months post-intervention.

Sampling and recruitment are described in detail elsewhere (13). Interviews with CHWs were conducted between 6 and 8 weeks following the smartphone training session in private offices at a local event centre in Singida. Interviews lasted between 1.5 to 2.5 hours. FGDs with women were conducted in private, central meeting locations, accessible by all participants (e.g. at a church, school, or village office) and each lasted between two and three hours. All interviews and FGDs were digitally recorded with the permission of participants.

Data Analysis

To ensure high quality transcripts, we followed a multi-stage process of transcription and translation, with a different bi-lingual research assistant (RA) responsible for each step, as follows: 1) one research assistant transcribed digitally recorded Swahili interviews verbatim; 2) a second RA translated Swahili transcripts into English; and 3) a third RA was responsible for cross-checking the data by listening to the original Swahili recording while reading along in English. Discrepancies were discussed and resolved as a team during weekly meetings.

Analysis of qualitative data was conducted using conventional content analysis (18). Interview transcripts were coded using NVivo for Mac software, version 10.2.1. Following the methodology outlined by Saldana (19) we adopted a two-staged coding approach. In the first coding cycle, a general framework was used to “chunk” data into sections according to broad, pre-determined topics outlined in interview and FGD guides. During this process, detailed analytic memos were used to summarize emergent themes, formulate hypotheses and to highlight narratives subjectively identified as particularly rich candidate texts for further exploration (20). The secondary coding cycle involved the use of more specific sub-codes to categorize participant statements into themes derived directly from the data (19). Secondary coding was applied to all transcripts, with particular attention to the rich sections previously identified through memoing.
Ethical Oversight

The Office of Research Ethics at the University of Toronto, Canada, the Tanzanian National Institute for Medical Research (NIMR) and the Tanzanian Commission for Science and Technology (COSTECH) approved the research protocol.

Results

Secret pregnancies and silent births: data security within the context of reproduction

Participants’ perceptions illustrate how privacy and confidentiality are particularly important with respect to women’s reproductive health, as pregnancy and childbirth are often kept secret in the Tanzanian context. One CHW noted that women refrain from announcing their pregnancies out of fear that disclosure “will cause other people to destroy their pregnancies” [SS13] through witchcraft. According to another CHW, women generally do not reveal their estimated delivery dates to neighbours, friends or even extended relatives, out of fear of being “bewitched” during childbirth:

“They do not say anything or even shout to show that their water broke due to the belief that if they cry or scream they will have bad luck in giving birth.” [SS32]

Focus groups with women confirmed these assertions, as participants described the influence of witchcraft and sorcery on fetal loss. Women often attributed complications 45 during pregnancy and childbirth to supernatural causes imposed by others:

Participant 1: “It has happened [in our village]. The mama was bewitched, and the pregnancy became stuck; it was not growing at all.”

Participant 2: “Some of us are afraid of being bewitched. It happened that a certain woman remained pregnant for almost one year. This happened in the village… and a lot of other people lost their pregnancy because of these issues.”

Researcher: So is that why women hide the pregnancy up until delivery?

45 Miscarriage, stillbirth, retained placenta, maternal and infant death were all named as possible consequences of witchcraft
Participant 3: “Yes. They are not saying anything; they just keep quiet. Even with your very close friend, you cannot tell her the truth. If she asks how old your pregnancy is, you just mention the wrong (number of) months.”

Participant 2: “Yes it’s true. If you tell them the (exact) months, they can start counting for you, which is very bad… when it reaches the day of delivery then they can do something bad to you. They can put something bad towards you so that you cannot have a safe delivery; you can even die or lose the baby.” [FGD4A]

When pressed to explain further, women’s discussions revealed a commonly held perception that miscarriage and birth complications often result from a complex combination of poverty, envy, jealousy and superstition. As one participant noted, “there are some women who don’t have children of their own so they feel envious of others [who become pregnant]” [FGD2B]. Other participants elaborated, suggesting that infertility, and feelings of jealousy motivate people to inflict witchcraft on pregnant women:

“Some people are bad because they don’t have children for themselves; they have tried every way and they have not become pregnant, so they will just bewitch you. Maybe she is your enemy so on the day of delivery you might die or the child might die. It’s because of the bad heart that they have.” [FGD2]

While infertility was noted as a reason for jealousy/envy, a few participants stated that even among women who already have children, “there are some who just have bad hearts, so they feel jealous” [FGD2B]. Having children was viewed as a blessing, and indicative of a family’s success; as one participant explained, there are some people who “just don’t want you to have any children… because no one likes to see somebody else’s development”. Confirming this sentiment, another participant noted, “Women who have bad hearts are “motivated by selfishness” and may wish to “see a gap left in your family” [FGD4].

Given that pregnancy and childbirth are perceived as periods of increased vulnerability to witchcraft, women are reluctant to reveal pregnancies and share details about estimated gestational age and due dates. When asked when it would be appropriate to share the news of an expectant child, women were quick to object to the suggestion:

“No you can’t! They [community members] will see it by themselves, and the pregnancy will speak for itself as it grows; you don’t have to go around announcing it.” [FGD3]
FGD participants suggested that boasting or “advertising the pregnancy” is frowned upon, and would be met with harsh criticism from other women in the community:

“If you tell someone about your pregnancy, people will start talking, and say ‘so and so said she is pregnant, I don’t know why she is announcing this to everyone. She’s crazy! Why is she announcing it? She must be very stupid.” [FGD5]

As another participant notes below, announcing one’s pregnancy is akin to bragging about how much food your family has to eat, which would simply be inappropriate in this context:

“It is the same as when you eat something at your home and then you tell people - today I ate rice with small fishes or, rice with beans… that it is not good, in front of people, that is your secret within the household only.” [FGD4]

Maintaining modesty and humility when met with good fortune was clearly an essential virtue among women in this study. A common perception was that failure to comply with acceptable behavior can increase one’s exposure to witchcraft. As one participant noted:

“If [a pregnant woman] goes around priding herself, then those who have a bad spirit will say ‘why is she announcing the pregnancy herself… let us show her’… she will get a problem the day of delivery because of that.” [FGD5]

Some women were so determined to keep their pregnancies secret that they reportedly wore loose-fitting clothes to hide their growing abdomens, and “held in the sickness” when other people were around. Women reported that it is common to deny being pregnant and make excuses for showing symptoms when questioned by other community members:

Participant: “When I’m pregnant, I vomit all the time and I have a fever, and everyone can see that.”

Interviewer: “What if people see these symptoms and ask if you are pregnant?”

Participant: “I cannot agree (nervous laughter). I just say that I have malaria” [FGD6]
Secrecy, trust and the role of CHWs

CHWs in both study groups felt strongly that maintaining confidentiality and protecting client privacy was critical to establishing long-term relationships built on mutual trust and solidarity. From women’s perspective, CHWs were respected as reliable members of their communities who could be trusted and confided in. Women considered CHWs to be especially valued confidants during pregnancy because they could relay MNCH information within the privacy of clients’ homes:

“You cannot tell everyone [about your pregnancy] because you cannot be loved by all people… that is why you keep it as a secret between yourself and your community health worker.” [FGD4]

Some clients contrasted CHWs with facility-based clinicians, stating that they felt closer to CHWs, but that the social distance was much wider between women and facility-based clinicians. This view was common across FGDs, as similar statements emerged in both SP+ and control villages:

“First of all, they are so charming… and they are humble when they come to visit you. You know, it’s not like when you go to the dispensary - the look you may get from the nurses makes you worry; you may even fail to explain your problems, but with community health workers we feel comfortable because when you reach the health facility, you greet each other and the CHW will start taking your records, and we are used to them because they are our home people.” – FGD2 (control)

“I mean they keep our secrets, that’s why we trust them. For example if you have been mistreated at the dispensary, you can speak to them and they go talk to the doctors without sharing your secrets. Those ones [facility-based clinicians] have different ethics from our CHWs […] she may give an example and explain to other women at the clinic - like someone has done this and this and sometimes they reveal your secrets and mention your name so all of the people there understand what happened to you. But the CHWs visit us at home, one at a time.” - FGD3 (SP+)
Given the apparent role of CHWs as trusted gatekeepers of women’s private information during pregnancy, and the importance of secrecy during pregnancy, we were interested to understand whether and how smartphone use by CHWs impacted perceptions regarding privacy and security among both CHWs and their clients.

Privacy, Confidentiality and Smartphones: CHW and Client Perceptions

According to CHWs in SP+ villages, an added value of the smartphone tool is improved confidentiality and consequently, increased trust in CHWs among clients, as exemplified in the following passage:

“For me the phone has an advantage. The closeness between my clients and me has increased because now when you visit a woman, she feels comfortable to tell you her secrets that she cannot tell anyone else. She knows you’re not writing on paper, which anyone can see. With the phone you cannot give information to anyone else unless the pin code is entered, so their secrets are safe […] Now when I go and tell her ‘I want to talk to you using the phone, and there are things I will type which will be a secret for me and you only’, she will sit and listen to me.” [SS51]

When asked about their clients’ perceptions of the phones, a majority of the CHWs provided positive feedback. Responses like the following were common:

“They perceive it in a good way and they know that their personal health records are being kept carefully and they are being sent somewhere that will help them.” [C28]

“It’s good now because the phone stores information secretly, not like the papers, where someone can easily see others’ information – with the paper [register books] someone can get to know other people’s problems. Women enjoy the phones because they store information secretly” [C49]

One CHW explicitly noted the benefit of smartphones in keeping women’s estimated delivery dates secret:
“The phone is only yours and so she [the client] feels her secret is safe with you. She knows that people may see her pregnancy but they won’t know when she’s going to give birth because the pin code protects the information” [C36]

While CHWs expressed consistently positive feedback with respect to smartphones and data security, this was one of the most contentious topics that emerged from FGDs with women. These narratives revealed a range of conflicting opinions on whether smartphones served as a protector or potential breach of women’s privacy. Several women had neutral opinions of the phones and trusted CHW to use them responsibly, stating for example, “it is okay for them to use phones because they have never done anything bad to us, their service is good, we have no doubts with them”. Others were adamant that smartphones were better than paper-based record books in terms of privacy protection:

“I have seen there is confidentiality because I have not heard any of my information from people in the streets. But I have noticed that on the paper forms, anyone can come and take the paper and read it. So if he/she knows how to read, the secret will be out, but it is not so easy with the phone.” [FGD1]

A woman from other FGDs shared a similar perspective:

“Ah yes, the phone is so secretive, because even if she gives it to you, you can’t open it, so you won’t see anything. And even if it’s open you can’t read if you don’t understand how it works, so it’s not easy to know other people’s information. Even if the message enters as you’re looking at it, you can still look without seeing other information that isn’t yours. But on the paper when she’s opening the files you can quickly see other people’s information if you’re fast enough” (laughter from the group). [FGD11]

Many women believed smartphones were more secure than paper-based registers because of the pin code required to access content. One participant stated, “if the phone gets lost, the one who picks it up will not be able to know the secrets inside… so they will just throw away the SIM card and replace it with a new one” [FGD9].
In contrast to the statements above, there were some women who worried that smartphones made it easier to spread sensitive information. One participant contemplated this possibility aloud:

“What if you said something bad and she recorded the information on the phone and later on she accidentally sends the information to her supervisors? It will cause some problems for us”. [FGD4]

In the same group, several other women highlighted the important role of household gender dynamics, noting that female CHWs may not be in control of the smartphone, and by extension, the data it stores:

Participant 1: “What if the health worker is married? Because the husband will definitely demand to see the phone, and because she will fear to lose her marriage she might share the information with her husband and then he will get to know all our secrets... that’s why I am not so happy with the phone.”

Participant 2: “Yes, men are so clever... he will start complaining that ‘sure the phone is used for work but why are you keeping secrets from me? What are you hiding from me?’ So because you want to serve your marriage you will just have to show him. Even if you’re in the bath taking a shower and the phone rings, he will look at it first before giving it to you. You know, men don’t always trust women and he may think you’re cheating if you don’t show him.” [FGD4]

This sparked a lively debate among participants, with some women quick to offer opposing views:

“For me I think it’s not easy for her husband to know because he will understand that the phone is only for work... because for us who are living with our husbands, if the phone rings he will just bring it to us. Unless we are in a fight, he will never look to see who is calling, so phones are the best.” [FGD4]

Another participant agreed that this was an unlikely scenario, since husbands would need to know exactly how to use the application:
“I agree, it’s not so easy… if he knows [the information] then she must have given him the pin and taught him what to do, but it’s not easy for him to search the information on his own, she must have told him what to do… it’s not that simple. As a health worker you know where the information for your clients is… it’s the health worker herself who will decide to tell her husband.” [FGD4]

Concerns regarding mobile phone ownership and who controls access to its contents did not apply to male CHWs; these perceptions only emerged with reference to female CHWs. None of the female CHWs interviewed confirmed whether their husbands requested to access client data, although they were not probed specifically on this subject during interviews.

Discussion

Study findings demonstrate that the use of new technologies to capture health data can have both positive and negative impacts on perceptions of personal privacy and confidentiality. The ability to store client information on a device that is only accessible with a pin-code was considered a major benefit by CHWs and many of their clients. CHWs were nearly unanimous in their belief that SP use led to improved data security and client privacy protection, stating that clients preferred to have their health information collected with devices rather than paper-based forms. The FGDs with clients, however, revealed a much more nuanced story. While some women felt their privacy was enhanced with SP use, others were conflicted or had serious reservations. This study suggests that opinions are divided on the implications of smartphone capture of client data for privacy and confidentiality. For most CHW and some women, the device is considered a powerful tool for keeping sensitive information on pregnancy private between women and their CHW, capable of rapid delivery of health knowledge and patient data between various levels of the health system (14). For other women, the recording of personal information during pregnancy potentially conflicts with powerful social norms that tend to keep information about pregnancy secret during a particularly vulnerable period, and thus creates uncertainty and even fear of exposure to reproductive threats among women intended to benefit from the technology.

While protecting patient privacy and confidentiality is critical in any healthcare setting, it is a particularly important consideration in the rural Tanzanian context, given the socially embedded need for secrecy surrounding pregnancy and childbirth. Findings related to pregnancy, jealousy
and witchcraft align closely with previous research conducted in Tanzania (21) and Mozambique (22, 23). In these contexts, pregnancy and childbirth are perceived as vulnerable periods that increase women’s and unborn children’s exposure to sorcery imposed by jealous neighbours and kin (20). As Chapman suggests, this stems from the belief that pregnancy is a marker of good fortune and “impending social wealth”, which can cause friction among individuals living in communities where resources are scarce (23). As a result, women opt to hide their pregnancies for as long as possible, and avoid revealing estimated delivery dates to others. In Mozambique, this led to delayed uptake of available antenatal services, and motivated women to instead seek prenatal care from alternative, informal providers “who address their experiences of reproductive vulnerability rooted in ruptured social relations and poverty” (p. 356) (22).

In the present study, CHWs seemed to buffer this possibility by visiting women privately in their homes. Participant narratives suggest that CHWs in this study are deeply respected by their clients and were well integrated into their communities. Because of this, CHWs have an intimate understanding and appreciation of women’s perceived need for secrecy and discretion during pregnancy. They can work confidentially with both women and their partners to provide education early in pregnancy, and can also help women to access antenatal clinic services. Many women viewed the smartphone as an additional level of privacy, which solidified their trust in CHWs. However, this perception was not universal. The SP+ application had positive privacy implications for some clients, but these interpretations were lost on others whose perceptions of how the data might be used and shared differed.

Some of the disagreement that emerged from FGDs with clients can be attributed to issues of access to collected information within CHWs’ households; this appeared to be influenced by gender dynamics. This concern is consistent with findings from a recent review, which found that mHealth interventions in developing countries sometimes inadvertently reinforce and perpetuate existing gender-based power imbalances (24). Evidence from various countries suggests that lack of support and approval from male heads of households can hamper the potential effectiveness of mHealth approaches, and may actually outweigh other benefits to women (24). There were no indications that SP ownership by female CHWs led to spousal conflict or data privacy breaches, however, regardless of whether women’s perceptions were
warranted, the belief that male family members could access personal information if they desired was clearly a troubling possibility for some participants.

Based on ethnographic research in Tanzania, Stark argues that while mobile telephony creates and intensifies social relations, people are not merely passive users of technology - they exercise agency, and find ways to adapt mobile communication channels to suit their own needs (25). In the present study, participant responses suggest that women were wary of this possibility. To curb women’s uncertainty and suspicion of SPs, and to ensure maintenance of strong, positive relationships between CHWs and their clients, consideration of potential social implications, as well as effective community engagement during the initial design phase of mHealth projects is crucial. CHW responses suggest that if they are managed well, SPs have real potential to improve women’s security and privacy. However, women’s perspectives also suggest that clients must be better informed of how data is stored, protected (particularly from CHW domestic partners), and transmitted if community trust in the devices is to be improved.

The findings have lessons for program design wherever smartphones are deployed to capture women’s health information in vulnerable communities. Although not directly probed in this study, we might infer that these considerations are important not only for pregnancy, but also for other sensitive health data collected by CHWs, such as HIV screening history and status, and information related to family planning and contraception, for example. If implementers are proactive in providing explicit information about how the technology works to manage and protect client data at the outset of a new mHealth program, then many of the client concerns noted here could be preemptively addressed, and clients could make informed decisions about what information they wish to supply with full knowledge of how it will be used. In particular, CHWs and other health care workers using mobile technologies need to be aware of and able to communicate how client data is protected, and how it could be compromised. Similarly, clients also need to be explicitly informed of how their data is being used, who has access to it, and what protections are in place to keep their data private.

These lessons are not only applicable in the mHealth sphere, but have implications for the use of mobile technology in development projects more broadly. When ICT4D projects are conceptualized, it is often assumed that they will result in the spread of ‘useful information’ (26), which in turn will lead to universally positive impacts. However, this study and others (26)
demonstrate that the introduction of new technologies can also lead to the novel spread of socially sensitive information normatively intended to be secret. Our study suggests that if privacy is breached, or if communities are worried their private information could be compromised, this may modify how intended beneficiaries interact with practitioners (in this case, CHWs), who play a key role in project implementation. Transparency and community engagement from the outset are likely essential to ensure that technology-focused interventions limit their impact as much as possible to their intended goals and do not trigger real or perceived privacy concerns.
References


13. Hackett et al. Impact of a smartphone-based decision support and counselling tool for community health workers on facility based delivery uptake: Results from a cluster-randomized intervention study in rural Tanzania. Forthcoming


Chapter 8
Discussion and Conclusion

Thesis summary

Through a series of studies presented in the previous four chapters, this thesis answers key questions in health services research and contributes to the evidence base for mobile health (“mHealth”), an important and rapidly evolving field globally. As detailed in Chapter 3, I employed a cluster-randomized, controlled, mixed methods trial design to study the process and impact of a smartphone intervention (SP+) designed to assist CHWs with data collection, counselling/education delivery, gestational danger sign identification, and patient referrals in Singida, Tanzania. To my knowledge, this will be the first peer-reviewed study looking at the effect of smartphone support for CHWs on FBD. It is also the first mHealth intervention study to explore potential pathways of behavior change.

The main outcome results (manuscript 1, Chapter 4) indicate that use of SP+ by CHWs was associated with increased health facility-based delivery, particularly among first time mothers with low levels of antenatal care uptake. Despite this positive result, I note that a number of other maternal and health systems factors (parity, previous FBD experience, ANC uptake, and presence of a public hospital) remained very strong independent predictors of FBD across both control and intervention groups. This suggests that while smartphone-support for CHWs clearly adds value, the factors influencing women’s capacity to access and decision to utilize facility services in this setting are multidimensional and interventions targeting improved FBD must take these factors into account.

Another important result from the first manuscript was that women in SP+ villages were significantly more likely to receive at least two home visits by CHWs during pregnancy; this was a key mechanism through which the effect of SP+ on FBD occurred. Findings presented in manuscript 2 (Chapter 5) contextualize this result by exploring CHW motivation and experiences at a more granular level. In this chapter, I draw from quantitative survey data to show that in the short term, CHWs equipped with SP+ had higher job satisfaction compared to CHWs in the control group. Analysis of CHW narratives offer additional insights into why this
was the case – CHWs perceived a number of important benefits of SP+ use (both task-related and with respect to their relationships with clients and communities), which may explain why they were motivated to conduct more household visits with pregnant clients on average (manuscript 1). The finding that job satisfaction did not differ significantly between SP+ and control groups six months later can be explained by the inherent challenges faced by CHWs on a day-to-day basis. These included logistic and technical difficulties, unanticipated community perceptions, and most critically – a lack of financial compensation for their work. This paper argues that equipping CHWs with SP tools does not substitute proper financial incentives, supportive supervision, and other sources of motivation and support.

A critical question to arise from the second manuscript is how to address the “novelty effect” problem in mHealth and other ICT-based interventions. Since job satisfaction attenuated over time among CHWs in the intervention group, critical questions regarding sustainability remain. If the length of the study had been extended to investigate changes in CHW activity beyond the ‘novelty’ period, the degree of impact on FBD may have different from what is reported in manuscript 1. This further emphasizes the need for additional investment in CHW salaries, refresher training, and other forms of CHW support in the long-term.

Manuscript 3 (Chapter 6) shows that CHWs using smartphones scored significantly higher on measures of quality of care by their female clients, compared to CHWs in the control group. As noted in manuscript 1, women living in SP+ villages were likely to receive more CHW home visits during pregnancy, thus it is possible that the higher quality of care scores simply reflect this increased exposure to CHW counselling during pregnancy. However, qualitative findings suggest a more nuanced explanation. Women’s narratives indicate that aspects of the technology itself may have amplified the positive experiences among some women and strengthened their relationships with CHWs. According to both CHWs (manuscript 2) and many of their clients (manuscript 3), added benefits of the SP+ intervention included improved communication, efficiency, and data management, and perceived enhancements in the credibility and accuracy of health knowledge provided during counselling sessions. SP+ use signaled overall improvements in health system accountability and a more serious government response to MNCH needs. Perspectives of both CHWs (Chapter 5) and their female clients (Chapter 6 and 7) demonstrate that the introduction of new ICTs can have important impacts on how communities perceive and interpret not only the quality of CHW services, but also the quality of the health system more
broadly. As argued in Chapter 6, if technology symbolizes improvements in the health system, then program implementers must work to ensure that these expectations are actually met. It would be unethical not to do so, as false expectations of the health system could increase service uptake in the short term, but threaten repeat utilization over time if services are unsatisfactory.

The fourth and final manuscript (chapter 7) explores perceptions regarding data security and privacy among CHWs and their female clients. While this was not a central research question initially, it emerged as an important theme during qualitative data collection from multiple sources, and therefore warranted special consideration. Women shared mixed opinions on whether smartphone-assisted data collection could strengthen or threaten their personal privacy and confidentiality. As FGD narratives illustrate, worries regarding data security are of particular concern within the context of reproduction due to the belief that women’s risk of exposure to witchcraft imposed by jealous neighbours and kin is heightened during pregnancy and childbirth. Implications of these perceptions can be interpreted from two perspectives. On the one hand, since the SP application requires CHWs to enter pin codes, and data is stored on password-protected servers, mHealth tools may be viewed as an opportunity to strengthen clients’ data security. However, if women are uncertain of how their information is protected, or believe that privacy breaches are possible, then the actual level of data security may be irrelevant. This highlights the need for program implementers to ensure that both CHWs and clients are properly informed of how their data is stored, used, and protected from project inception. This paper also draws attention to the need for more stringent and comprehensive data protection policies at national and local levels to ensure that privacy precautions are implemented consistently across projects.

**Study limitations and opportunities for future research**

First, although a number of health behaviour change theories were reviewed to inform the development of this study’s logic model (Figure 4, Chapter 3), I was not in a position to apply any specific theory during the development of the SP application. World Vision had already elected to use a job aid for CHWs prior to my involvement in the project, and therefore it was not possible to design the intervention around specific theoretical constructs. Future studies would benefit from the approach employed by Strachan and colleagues, whereby theoretically grounded formative research on frontline health worker motivation is completed prior to
intervention design. Results of this work could then inform the development of more tailored, context-appropriate ICT-based solutions (Strachan et al. 2015).

Secondly, because the study was conducted within the context of a program that covered a limited geographical area, it was not feasible to mask SP+ intervention allocation, and over time, CHWs in the control group became aware that other SUSTAIN project CHWs had been given job aids. Future studies could consider enrolling CHWs from different programmatic and geographical areas to avoid study contamination, however this would require a robust design to account for various regional environmental differences.

Third, a number of predictors of FBD (e.g. ethnic group, use of health insurance, husband/partner’s education) were not captured in this analysis and may have unmeasured impacts on women’s uptake of FBD. Similarly, there may be additional pathways to impact that have not been adequately explored in this analysis. For example, it would have been interesting to assess the role of individual CHW characteristics such as sex, experience, age, workload and self-efficacy on women’s use of health services by controlling for these factors in GEE analyses. However, given that women were often counselled by both CHWs in each village on different occasions, it was not possible to link each client to a specific health worker. Future studies could be designed to track CHW-client interactions more systematically.

Fourth, this study reports on data collected over a period of approximately one year, and therefore cannot answer critical questions regarding sustainability of mHealth interventions in Tanzania. A stepped wedge randomized trial design may be most appropriate for future implementation science in this area. In a stepped wedged design, the intervention is rolled out sequentially over a number of time periods, which allows researchers to model the effect of time on the effectiveness of the intervention (Brown and Lilford 2006). Such a design could address gaps in the literature regarding the “novelty effect” discussed above, by identify specific points of entry for re-training, or other opportunities to increase health worker motivation.

Lastly, the study may have been strengthened if a baseline comparison measure of FBD were available at the village level, or if clusters were initially matched using additional criteria other than population size. However, I have no reason to believe that baseline FBD rates were
different in SP+ villages compared to control villages. Furthermore, randomization and statistical adjustment for village-level effects should have minimized this potential limitation.

Despite the limitations outlined above, this study was strengthened by its rigorous design, and its use of both qualitative and quantitative methods to triangulate data from multiple sources. This research contributes novel evidence in support if mHealth approaches in LMICs, while acknowledging the inherent limitations associated with technology-centered approaches to improving maternal health behaviour outcomes. Additional implementation and ethnographic studies are recommended to further explore potential pathways to impact.

Conclusion

Across all manuscripts, study findings in general agree with other research demonstrating the potential role of CHWs as key drivers of universal primary healthcare coverage, and effective providers of MNCH service in particular (for reviews, see: Perry, Zulliger, and Rogers 2014; Lehmann and Sanders 2007; Global Health Workforce Alliance and World Health Organization 2010; Lewin et al. 2010). Participant narratives demonstrate that in general, CHWs are trusted community mobilizers who provide a crucial link between health authorities, facility-level clinicians and individual patients and their families. In this sense, CHWs are highly valued “cultural translators” in this context, and therefore have great potential to contribute to positive MNCH outcomes, particularly where human resources for health are scarce. Despite this potential, indications are that CHWs were not adequately equipped or supported in the study areas at the time data were collected. To maximize potential gains from CHW work and to ensure sustainability of programs, proper financial incentives, supportive supervision, and other sources of motivation and assistance must be provided.

Based on study results and experiences working with CHWs in the SUSTAIN project, I echo the advocacy of other scholars who have called for greater attention to CHWs’ own wellbeing through provision of fair compensation and improved livelihood security (Closser 2015; Maes 2015). In a recent Lancet article, Pfeiffer and Chapman share their perspectives on the role of technologies and other targeted innovations to address “grand challenges” in global health:

“... All are vital efforts, but most will be heaped upon already overwhelmed health workers working in difficult conditions. Because of higher level workforce shortages, we
often focus on task shifting to lower level staff for new programmes. We should perhaps call it task multiplication for the same health workers who each year are asked to do more and more.” (Pfeiffer and Chapman 2015, p. 2145)

The authors rightfully point out that without first investing adequately in African public health sector systems, innovations cannot be effectively delivered, and in order to achieve such investments, priority setting by donors will need to be shifted.

Ultimately, smartphone support for CHWs appears to be one positive method for increasing FBD, and may be particularly efficacious as one component of a broader intervention package designed to increase uptake of safe facility delivery. These positive indications provide a strong rationale for investing in further research to measure cost effectiveness and evaluate the potential for further scale-up. However, there are myriad factors influencing FBD in this context, and although smartphone-based tools for CHWs may help to increase women’s demand for services, they cannot address systemic barriers to service uptake, or improve the quality of services provided once women arrive at facilities. ICT applications should therefore be viewed as complementary tools to strengthen existing MNCH service delivery systems and behaviour change communication approaches, rather than autonomous solutions.

This dissertation makes several key theoretical and empirical contributions to health systems scholarship in low-income countries (LICs). Methodological contributions include the use of a rigorous, multi-method design to study the impacts of an mHealth intervention for CHWs; to date, such studies have been scarce in LICs. Novel empirical insights extend current health behaviour change theorizing, particularly as it relates to mHealth programming. For example, to my knowledge, this is the first mHealth intervention study in a LIC to explore potential pathways of behavior change. I found that CHWs trained on SP+ were a) more satisfied with their jobs in the short term, and b) conducted more frequent household visits with clients during pregnancy. This suggests that increasing women’s exposure to CHW counselling is a key driver of maternal health service uptake. At the same time, qualitative indications are that other aspects of smartphone-based counselling may change women’s perceptions of the health system more broadly. Future studies to investigate these ideas in further detail are recommended.
References


Appendix A
Informed consent forms

Informed Consent Form (CHWs)

Baseline Survey - Data collection Point 1

Study Title: Village Health Workers & Women’s Access to Maternal Health Services in Rural Tanzania

Good morning/afternoon,

My name is ____________________ . I am a research assistant helping with a study by the University of Toronto, in Canada and World Vision. Today we invite you to participate in this research.

Introductory Information:

In this study, we want to learn more about what it is like to be a community health worker. We want to hear about things you like about your job and things that make your job difficult. We want to hear about World Vision’s trainings and new job aids. We want to know if you find them useful. We would like to hear about your experiences both good and bad. We also want to learn about the health of pregnant women and mothers in your community. We would like to understand why some women can/do access healthcare during pregnancy while others cannot/do not. Finally, we want to know whether you feel the tools and trainings you have been given can help to improve the health of women and children.

Conditions for participating:

It is completely up to you to decide whether to participate. Your decision will not affect any current or future participation in World Vision programs. Your current or future employment within the Tanzanian health system will not be affected. You should not feel pressured to participate in the research. If you do agree to participate, you will be asked to complete a short survey and in-depth interview with me today.

If you agree to participate it is OK to change your mind later. If you decide that you no longer want to be part of the study, you may withdraw at any time. You may withdraw even after the survey/interview is complete. In this case, records of the information you provided will be

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destroyed. Withdrawing from the study will have no negative consequences and will not influence your current or future work as a health worker.

Risks and Benefits:

The risk of this research is very low. Some questions might make you feel anxious, embarrassed or uncomfortable. You do not have to answer questions that make you feel uncomfortable. There is a risk of privacy and confidentiality loss in this study. We will lower this risk by keeping your information private.

We will be talking to your women clients in another part of the study. If clients report that the care you provide is unprofessional or unethical, we must report this to World Vision staff.

There is no direct personal benefit for joining this study. But information you share will help World Vision improve community health projects. Maternal and child health may also be improved. You will be reimbursed today for the cost of travel to Aqua Hotel. The survey and interview today will last about 2 hours.

Access to information, confidentiality, and publication of results:

Only members of the research team will have access to information you share. All data will be kept private. Your participation means that you allow the information to be used for research purposes. Your name, and any other identifying information, will not be included in reports or presentations. Researchers will share results of final analysis with World Vision. But World Vision will not have access to the raw data you provide today.

We will publish our findings in research articles and discuss them at conference meetings. At the end of the study, the research team will share the findings with you during a community meeting. This meeting will be organized by World Vision Tanzania.

You are free to withdraw from the study at any time. If you wish to withdraw from the study, please contact Dr. Peter Nyella of World Vision Tanzania at +255 783 730 467. If you withdraw, we will keep and analyze the data you have already provided. You may withdraw from the study up until June 2014. If you have questions about your rights as a participant, you can contact the National Institute for Medical Research at +255222121400. You may keep a signed copy of this form if you wish.

Do you have any questions about the study?

Signature:

By signing this form, you agree that:

1) The researcher has explained the study and answered all of your questions.
2) The researcher has explained the possible risks and benefits of this study.
3) You understand that you have the right not to take part in the study and to stop at any time.
4) You are free now, and in the future, to ask questions about the study.
5) Your answers will be kept private.
6) You understand that no information about who you are will be published or shared with others.

Participant’s ID Number (Printed by researcher): ________________________________

Participant’s Name (Printed): ________________________________

Can we contact you again to participate in further research activities for this study?
Yes ☐ No ☐

Signature of Participant: ________________________________
Consent Form (Women – VHW clients)

Focus Group Discussion – Data collection point 1

Study title: Village Health Workers and Maternal Healthcare Access in Rural Tanzania

Good morning/afternoon,

My name is ______________________. I am working with a study by the University of Toronto, in Canada and World Vision.

Introduction:

We want to learn about your experiences with village health workers. We also want to hear about your use of health services during pregnancy, childbirth and after the babies are born. We want to know how you feel about the health services in your community. This information will help to improve the health system in the future.

Risks and Benefits:

The risk of this research is low. Some questions might make you feel anxious, embarrassed or shy. You do not have to answer questions that make you feel uncomfortable. There is a risk of privacy and confidentiality loss in this study. We will lower this risk by keeping your information private.

We are talking in a group setting so we cannot guarantee confidentiality. Other participants will hear your answers. You should not share information that you do not feel comfortable sharing. Please respect the privacy of other study participants. Please do not repeat anything we discuss outside of this meeting.

There is no direct personal benefit for joining this study. But information you share will help World Vision improve community health projects. Maternal and child health may also be improved. If you decide to participate, you will be asked to join a group discussion today. This discussion will last one or two hours.

Access to information, confidentiality, and publication of results:

Only members of the research team will have access to information you share. All data will be kept private. Your participation means that you allow the information to be used for research purposes. Your name, and any other identifying information, will not be included in reports or
presentations. **Researchers will share results of final analysis with World Vision. But World Vision will not have access to the raw data you provide today.**

We will publish our findings in research articles and discuss them at conference meetings. At the end of the study, the research team will share the findings with you during a community meeting. This meeting will be organized by World Vision Tanzania.

**You are free to withdraw from the study any time before June 2014. You do not have to give a reason for withdrawing.** If you wish to withdraw from the study, please contact Dr. Peter Nyella of World Vision Tanzania at +255 783 730 467. If you withdraw, we will keep and analyze the data you have already provided. You may withdraw from the study up until June 2014. If you have questions about your rights as a participant, you can contact the National Institute for Medical Research at +255222121400. You may keep a signed copy of this form if you wish.

Does anyone have any questions about the research study?

**Signatures**

1) Focus Group Facilitator:

I certify that the volunteer named _______________________________ has been:
- o given all the above information about the research project.
- o told the purpose of the research.
- o told what will happen in the research.
- o told the risks involved in being in the research.
- o told that she can take a signed copy of this consent form if she wishes.
- o given time to ask questions about the research project.
- o and that I have answered her questions to the best of my ability.

I further certify that I have read this letter to the person named above.

Facilitator’s Signature ____________________________ Date

2) Research Participant:

*To be read aloud by interviewer:*

By signing this form, you agree that:

1) The researcher has explained the study and answered all of your questions.
2) The researcher has explained the possible risks and benefits of this study.
3) You understand that you have the right not to take part in the study and to stop at any time.
4) You are free now, and in the future, to ask questions about the study.
5) Your answers will be kept private.
6) You understand that no information about who you are will be published or shared with others.

| Participant’s ID Number (Printed by researcher): | ____________________________ |
| Can we tape record the interview? For researcher: | **Circle Yes / No** |
| Participant’s Name (Printed): | ____________________________ |
| Can we contact you to participate in other research activities for this study? | Yes ☐ No ☐ |
| Signature or Thumb Print of Participant: | ____________________________ |
Consent Form (Women – CHW clients)

Household Survey & Programmatic Data Release
Data Collection point 2

Study Title: Community health workers and Maternal Healthcare in Rural Tanzania

Good morning/afternoon,

My name is ______________________. I am working with a study by the University of Toronto, in Canada and World Vision.

Introduction:

In this study, we want to learn about your experiences with community health workers. We also want to hear about your use of health services during pregnancy, childbirth and after the babies are born. We want to know how you feel about the health services in your community. This information will help improve the health system in the future.

Description of the Research:

PART A: Today’s survey will take about 45 minutes to complete. We will be using a tablet device to ask you questions and record your answers.

PART B: Your community health workers collect medical data about you and your family. Information from CHWs’ registers is shared with World Vision and the Ministry of Health and is used for planning World Vision’s health program. To use your information in the University of Toronto project, we must request your permission. If you agree to participate, the research team will not know your identity and your name will never be linked to this data. We will keep all information confidential.

Risks and Benefits:

The risk of this research is low. Some questions in the survey might make you feel anxious, embarrassed or uncomfortable. You do not have to answer questions that make you feel uncomfortable. There is a risk of privacy and confidentiality loss in this study. We will lower this risk by keeping your information private.

There is no direct personal benefit for joining this study. But information you share will help World Vision improve community health projects. Maternal and child health may also be improved. If you decide to participate today, you will participate in a survey.

Access to information, confidentiality, and publication of results:
Only members of the research team will have access to information you shared. All data will be kept private. Your participation means that you allow the information to be used for research purposes. Your name, and any other identifying information, will not be included in reports or presentations. Researchers will share results of final analysis with World Vision. But World Vision will not have access to the raw data you provide today.

We will publish our findings in research articles and discuss them at conference meetings. At the end of the study, the research team will share the findings with you during a community meeting. This meeting will be organized by World Vision Tanzania.

You are free to withdraw from the study any time before July 2014. You do not have to give a reason for withdrawing. If you wish to leave the study, please contact Dr. Peter Nyella of World Vision Tanzania at +255 783 730 467. If you decide to withdraw, we will keep and analyze the data you have already provided. If you have questions about your rights as a participant, you can contact of the National Institute for Medical Research (NIMR) at +255 222 121 400. You may keep a signed copy of this form if you wish.

Do you have any questions for me before I begin?

Signatures:

1) Data Collector:

I certify that the participant (named below) has been:

- Given all the above information about the research project.
- Told the purpose of the research.
- Told what will happen in the research.
- Told the risks involved in being in the research.
- Told that she can take a signed copy of this consent form if she wishes.
- Given time to ask questions about the research project.
- And that I have answered her questions to the best of my ability.

I further certify that I have read this letter to the person named above.

Data Collector’s Signature ____________________ Date ___________________

2) Research Participant:

To be read aloud by interviewer:

By signing this form, you agree that:

- The researcher has explained the study and answered all of your questions.
- The researcher has explained the possible risks and benefits of this study.
- You understand that you have the right not to take part in the study and to stop at any time.
- You are free now, and in the future, to ask questions about the study.
- Your answers will be kept private.
- You understand that no information about who you are will be published or shared with others.
| Participant’s ID Number (Printed by researcher): | ______________ |
| Participant’s Name (Printed): | ____________________________ |

**Part A:** Do you wish to participate in a survey today?

Yes [ ]  No [ ]

**Part B:** Do you give permission to researchers to use your health information from CHW registers?

Yes [ ]  No [ ]

Signature or Thumb Print of Participant: ____________________________
Consent Form (Health Facility/Dispensary Staff)

Study Title: Village Health Workers & Women’s Access to Maternal Health Services in Rural Tanzania

Good morning/afternoon,

My name is ______________________ and I am a research assistant helping with a study by the University of Toronto, in Canada and World Vision. Today we are inviting you to participate in this research.

Introductory Information:

In this study, we want to learn more about women’s access to health services during pregnancy and childbirth. We are interested to know whether you feel village health workers (VHWs) can help women to access these services. Because you work in a dispensary and interact with VHWs and women patients, we are interested in your perspectives. We want to hear your thoughts about World Vision’s trainings and new job aids for VHWs. We would like to hear about your experiences with mothers and VHWs, both good and bad. We also want to know about the health of pregnant women and mothers in your community. We would like to understand why, in your opinion, some women access healthcare during pregnancy while others do not.

Conditions for participating:

It is completely up to you to decide whether or not to participate. Your decision will not affect any current or future participation in World Vision programs and/or your current or future employment within the Tanzanian health system. You should not feel pressured to participate in the research. If you do agree to participate, you will be asked to participate in an interview today.

Risks and Benefits:

The risk of this research is low. However, there is a small chance that you might feel anxious, embarrassed or uncomfortable about answering some questions. You do not have to answer questions that make you feel uncomfortable. There is a risk of loss of privacy and confidentiality for participants in this study. However, we will take appropriate steps to minimize these risks. For example, the information you provide will not be linked to any personal information, and all data will be stored on password-protected computers. Research team members will keep your information to themselves and every effort to ensure your privacy will be made.
There is no direct personal benefit for participation in this research. However, information you provide may be used to help support community health programs in the future. The information you give us will help World Vision and other NGOs to strengthen community health projects and improve maternal and child health.

**Access to information, confidentiality, and publication of results:**

Only members of the research team will have access to the information you provide. All information you provide will be kept confidential by the research team. Your participation means that you agree to allow the information to be used for research purposes, but your name, and any other identifying information, will not be included in reports or publications. Researchers will share results of final analysis with World Vision. But World Vision will not have access to the raw data you provide today.

After analyzing the data we will publish our findings through research articles and discuss them at conference meetings. At the end of the study, the research team will also communicate the findings with you and your colleagues at a meeting coordinated by World Vision Tanzania.

You are free to withdraw from the study any time before June 2014. You do not have to give a reason for withdrawing. Leaving the study will have no negative consequences and will not influence your current or future work as a health worker. If you wish to withdraw from the study, please contact Dr. Peter Nyella of World Vision Tanzania at +255 783 730 467. If you withdraw, we will keep and analyze the data you have already provided. You may withdraw from the study up until June 2014. If you have questions about your rights as a participant, you can contact the National Institute for Medical Research at +255222121400. You may keep a signed copy of this form if you wish.

Do you have any questions about the study?

**Signature:**

By signing this form, you agree that:

- The researcher has explained the study and answered all of your questions.
- The researcher has explained the possible harms and benefits of this study.
- You understand that you have the right not to take part in the study and to stop at any time.
- You are free now, and in the future, to ask questions about the study.
- Your answers will be kept private.
- You understand that no information about who you are will be published or shared with others.
Participant’s ID Number (Printed by researcher): _______________________________

Participant’s Name (Printed): _______________________________

Signature of Participant: _________________________________

Can I begin the interview now?
Focus Group Discussion Guide (Pregnant Women – CHW Clients)

ADMINISTRATIVE INFORMATION:

<table>
<thead>
<tr>
<th>Name of FGD facilitator:</th>
<th>Village ID:</th>
</tr>
</thead>
<tbody>
<tr>
<td>FGD facilitator signature:</td>
<td>--------------</td>
</tr>
<tr>
<td>Date of survey:</td>
<td>Participant ID:</td>
</tr>
<tr>
<td>------- / ------- / ---------</td>
<td>--------------</td>
</tr>
<tr>
<td>(day / month / year)</td>
<td></td>
</tr>
</tbody>
</table>

FGD start time:

____ ____ : ____ ____
(hour) (min)

Questions to guide discussion:

A) Interactions with VHWs

1. We would like to learn more about women’s relationship with VHWs in your community.
   Can you tell us about women’s interactions with VHWs?
   - How often do VHWs visit women in your families?
     - If yes, do they schedule appointments?
   - Do women contact VHWs?
     - How?
2. Do women in your community feel comfortable seeking health care services and information/advice from VHWs?
   a. Why or why not?
   b. What makes you feel this way?

3. How knowledgeable are VHWs about maternal and child health issues?

4. Are women in your community satisfied with the quality of care and services offered by VHWs?
   • Why or why not?

**For experimental/mHealth group only:
Probe specifically about satisfaction with mobile phone use…

   • VHWs in your locality have been using mobile phones. Do women like this?
     o Why or why not?
   • What is good about the mobile phones?
   • What is bad about the mobile phones?
   • Now that they have mobile phones, do VHWs spend more time or less time with clients?
   • Is the quality of care better or worse now that VHWs use mobile phones?
   • What is the best thing about the phones used by VHWs?
   • Do the phones help women and families to learn about maternal and child health?

5. What would women in your families say is the best thing about having VHWs in your community?

B) Barriers to Antenatal Care Access

6. Can you describe the kind of healthcare that women should receive during pregnancy?
   (both at the facility and at home)
   a. What services are supposed to be available to pregnant women?
   b. How many times should women have antenatal care during pregnancy?

7. Is it difficult for women in your community to access health care services during pregnancy?
   • Why or why not?
   • What makes healthcare access difficult during pregnancy?
   • What would make healthcare access easier during pregnancy?

*Probes:
- availability of services (do they exist?)
- accessibility (distance, transportation issues)
- affordability/cost issues
- adequacy (do the services available meet the clients’ needs?)
- do women have the freedom (power) to access these services?
- Does everyone agree? Does anyone feel differently?
8. At what point does a woman realize that she is pregnant (how far into pregnancy, and how does she know)?
   a. Do most women keep this a secret?
   b. Why or why not?
   c. Who do women tell first about their pregnancy?
   d. How do husbands find out? How do they react?
   e. When is the best time to tell people about a pregnancy?
   f. How far into pregnancy should women seek healthcare?

9. Do husbands or other male family members ever accompany women to antenatal visits?
   - Why or why not?
   - Should husbands accompany women? Why or why not?

10. In your community, how satisfied are women with health services offered during pregnancy?

11. How do clinic staffs interact with pregnant women at the dispensary/hospital?
   - Are women treated kindly?
   - What is this experience like?
   - Does anyone have any experience they would like to share?

12. Is there anything about antenatal care services that could be improved in your community?

C) Barriers to Facility-based Delivery:

*Probes:
- If the pregnancy is secret, how do women go for antenatal care at the clinic?
- How do women keep pregnancies a secret? (loose clothing?)
- Why don’t women seek antenatal care early in pregnancy?
- What is considered a “normal” pregnancy?
  - How do they know the pregnancy is normal?

*Probe:
- Are women treated differently during pregnancy? How so?
- Does everyone agree?

*Note: This can include services offered both at the clinic and in the community/household.
13. Where do most women give birth in your community?

14. Where do most women prefer to give birth?
   - Why is this the preferred location?

15. Where would you like to deliver your next baby?

16. Who would you prefer to have help with the birth?

17. Can you tell me about traditional birth attendants? Have any of you asked TBAs to assist during previous deliveries? Please share your experiences.

18. Why do you think some women prefer TBAs while others prefer doctors or nurses in the clinic?

19. How do TBAs interact with women?
   - Are women treated kindly by TBAs?
   - What are your experiences with TBAs like?
   - Does anyone have any experience they would like to share?

20. Who makes decisions about where to give birth?
   - Why does this person make the decisions?
   - How do women feel about this?

21. Do husbands ever accompany women during the delivery? Why or why not? Should husbands accompany women? Why or why not?

22. Is it difficult to access a health professional during delivery?
   - Why or why not?

23. What are some of the difficulties faced by health professionals (facility staff) during labour and delivery?
24. How do health staffs interact with pregnant women when they go to give birth at the dispensary/hospital? Are women treated kindly? What is this experience like? Does anyone have any experience they would like to share?

25. Of all the things we discussed today, what do you think is most important?

26. Is there anything else you would like to tell us about pregnancy and/or childbirth in your community?

Thank you for your time today. We really appreciate your help with this research.
FGD end time:

____ ____ : ____ ____
(hour)           (min)
Health Facility Assessment Checklist

**Administrative Information:**

<table>
<thead>
<tr>
<th>Name of data collector:</th>
<th>Health Facility ID:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>__________</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data collector’s signature:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date of assessment:</th>
<th>Time of Assessment:</th>
<th>Health Facility Type:</th>
</tr>
</thead>
<tbody>
<tr>
<td><em><strong><strong>/</strong></strong></em>/_____</td>
<td><em><strong><strong>:</strong></strong></em></td>
<td>Dispensary ------------</td>
</tr>
<tr>
<td>(day) (month) (year)</td>
<td>(hour) (min) AM/PM</td>
<td>Health Centre --------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hospital --------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>______</td>
</tr>
</tbody>
</table>

**HEALTH FACILITY CHECKLIST**

Observe to see if each of the following structures exists in the health facility. If it does exist, ask the health staff to show it to you and inspect as necessary. For each question, write the code number for the appropriate answer in the far right column.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Does this facility have overnight or in-patient beds?</td>
<td>Yes, observed -------- 1&lt;br&gt;Yes, reported -------- 2&lt;br&gt;No -------- 3</td>
<td></td>
</tr>
<tr>
<td>1. b) If yes, how many?</td>
<td>__________</td>
<td></td>
</tr>
<tr>
<td>2. Is there 24-hour staff coverage at this facility?</td>
<td>Yes -------- 1&lt;br&gt;No -------- 2</td>
<td></td>
</tr>
<tr>
<td>3. Does this facility have a working phone or shortwave radio that is available at all times client services are offered?</td>
<td>Yes, landline -------- 1&lt;br&gt;Yes, HW cell phone only ---- 2&lt;br&gt;No -------- 3</td>
<td></td>
</tr>
<tr>
<td>4. Does this facility have a functional ambulance or other vehicle on site for emergency transport of</td>
<td>Yes, observed functioning, with fuel --- 1&lt;br&gt;Yes, reported functioning, with fuel ----</td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td>Options</td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>----------------------------------</td>
<td></td>
</tr>
<tr>
<td>Does this facility have electricity functioning now?</td>
<td>Yes, observed</td>
<td>No</td>
</tr>
<tr>
<td><strong>COUNT AS “YES, OBSERVED” IF ELECTRICITY IS OBVIOUSLY RUNNING OR IF YOU CAN TURN ON AN ELECTRICAL SWITCH AND GET ELECTRICITY.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does this facility have a back-up or standby generator for electricity?</td>
<td>Yes, observed</td>
<td>Yes, reported</td>
</tr>
<tr>
<td>Is there a toilet or latrine that is available for clients to use?</td>
<td>Yes, observed</td>
<td>Yes, reported</td>
</tr>
<tr>
<td><strong>THIS TOILET/LATRINE MUST BE FOR THE USE OF CLIENTS, NOT JUST HEALTH FACILITY STAFF</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ASK TO SEE THE TOILET OR LATRINE AND INDICATE THE TYPE.</strong></td>
<td>VIP latrine or Flush toilet</td>
<td>Traditional or open pit latrine</td>
</tr>
<tr>
<td>9. Does the health facility have water available today?</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>10. Does this health facility have running water?</td>
<td>Yes, observed</td>
<td>Yes (reported) but not functional today</td>
</tr>
<tr>
<td><strong>CHECK TAPS.</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. What is the source of water in this health facility?</td>
<td>Piped into facility</td>
<td>Piped onto facility grounds</td>
</tr>
<tr>
<td>Used Water Source</td>
<td>Bottled water</td>
<td>Rain water or surface water</td>
</tr>
<tr>
<td>-------------------</td>
<td>--------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>12. Does this facility have a refrigerator for storing vaccines?</td>
<td>Yes, observed</td>
<td>Yes, reported</td>
</tr>
<tr>
<td>13. Is the refrigerator functioning?</td>
<td>Yes, observed</td>
<td>Yes, reported</td>
</tr>
<tr>
<td>14. Does this facility have oxytocin in stock today?</td>
<td>Yes, observed</td>
<td>Yes, reported</td>
</tr>
<tr>
<td>15. Does the facility have tetanus toxoid vaccines in stock today?</td>
<td>Yes, observed</td>
<td>Yes, reported</td>
</tr>
<tr>
<td>16. Does the facility have BCG vaccines in stock today?</td>
<td>Yes, observed</td>
<td>Yes, reported</td>
</tr>
<tr>
<td>17. Does the facility have OPV (Polio) vaccines in stock today?</td>
<td>Yes, observed</td>
<td>Yes, reported</td>
</tr>
<tr>
<td>18. Does the facility have Measles or MMR vaccines in stock today?</td>
<td>Yes, observed</td>
<td>Yes, reported</td>
</tr>
<tr>
<td>19. Does the facility have the DPT or Pentavalent vaccines in stock today?</td>
<td>Yes, observed</td>
<td>Yes, reported</td>
</tr>
<tr>
<td>20. Does the facility have syringes in sterile packets in stock today?</td>
<td>Yes, observed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Question</td>
<td>Yes, observed</td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>21</td>
<td>Does the facility have any 19- or 21-gauge needles in sterile packet in stock today? (may be with syringe)</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Does the facility have eclampsia (MgSO4) medication in stock today?</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Does this facility have a neonatal resuscitation device (tube and mask or bag and mask)?</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Does this facility have a functioning infant scale?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>IF THERE IS A SCALE PRESENT BUT IT IS NOT FUNCTIONAL, SELECT “NO”.</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Does this facility have delivery kits in stock?</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>How many delivery kits are in stock?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>COUNT THE NUMBER OF DELIVERY KITS.</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Does the facility have malaria-testing kits in stock today?</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Does the facility have HIV-testing kits in stock today?</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Does the facility have syphilis testing kits in stock</td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td>Yes, observed</td>
<td>Yes, reported</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>--------------</td>
<td>--------------</td>
</tr>
<tr>
<td>30. Does this facility have ARVs in stock today?</td>
<td>---------------</td>
<td>--------------</td>
</tr>
<tr>
<td>31. Does the facility have malaria prophylaxis in stock today?</td>
<td>---------------</td>
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</tr>
<tr>
<td>32. Does the facility have Iron/folic acid supplements in stock today?</td>
<td>---------------</td>
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</tr>
<tr>
<td>33. Does the facility have vouchers for insecticide-treated bed nets (ITNs) in stock today?</td>
<td>---------------</td>
<td>--------------</td>
</tr>
<tr>
<td>34. Does the facility have a functioning blood pressure machine?</td>
<td>---------------</td>
<td>--------------</td>
</tr>
<tr>
<td>35. Does the facility have chlorine-based disinfectant available for use in the delivery room?</td>
<td>---------------</td>
<td>--------------</td>
</tr>
<tr>
<td>36. Does the facility have a private delivery room (must be separate from other clinic areas)?</td>
<td>---------------</td>
<td>--------------</td>
</tr>
<tr>
<td>37. How many beds are present in the delivery area/room?</td>
<td>---------------</td>
<td>--------------</td>
</tr>
<tr>
<td>38. Does this facility have a separate post-delivery room where mothers and infants can rest following delivery?</td>
<td>---------------</td>
<td>--------------</td>
</tr>
<tr>
<td>39. ASK FACILITY STAFF: On average, how long are</td>
<td>---------------</td>
<td>--------------</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>today?</th>
<th>No</th>
<th>3</th>
</tr>
</thead>
</table>

<p>| 30. | Yes | 1 |
| 31. | Yes | 2 |
| 32. | Yes | 2 |
| 33. | Yes | 2 |
| 34. | Yes | 2 |
| 35. | Yes | 2 |
| 36. | Yes | 2 |
| 37. | | _______ beds |
| 38. | Yes | 1 |
| 39. | | |</p>
<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>mothers permitted to stay at the facility following delivery?</td>
<td>________ hours / day(s) (circle one)</td>
</tr>
<tr>
<td>STAFFING OF HEALTH FACILITY</td>
<td></td>
</tr>
<tr>
<td>40. Total number of staff members at this facility?</td>
<td></td>
</tr>
<tr>
<td>41. Number of physicians on staff?</td>
<td></td>
</tr>
<tr>
<td>42. How many days per week does each physician work in the health facility?</td>
<td></td>
</tr>
<tr>
<td>a) ________ days</td>
<td></td>
</tr>
<tr>
<td>b) ________ days</td>
<td></td>
</tr>
<tr>
<td>43. Number of clinical officers on staff?</td>
<td></td>
</tr>
<tr>
<td>44. How many days per week does each clinical officer work in the health facility?</td>
<td></td>
</tr>
<tr>
<td>a) ________ days</td>
<td></td>
</tr>
<tr>
<td>b) ________ days</td>
<td></td>
</tr>
<tr>
<td>45. Number of medical assistants on staff?</td>
<td></td>
</tr>
<tr>
<td>46. How many days per week does each medical assistant work in the health facility?</td>
<td></td>
</tr>
<tr>
<td>a) ________ days</td>
<td>b) ________ days</td>
</tr>
<tr>
<td>47. Number of MCH heads on staff?</td>
<td></td>
</tr>
<tr>
<td>48. How many days per week does each MCH head work in the health facility?</td>
<td></td>
</tr>
<tr>
<td>a) ________ days</td>
<td>b) ________ days</td>
</tr>
<tr>
<td>49. Number of nurses on staff?</td>
<td></td>
</tr>
</tbody>
</table>
50. How many days per week does each nurse work in the health facility?
   
   a) _______ days
   b) _______ days
   c) _______ days
   d) _______ days

51. Number of midwives on staff?

52. How many days per week does each nurse work in the health facility?
   
   a) _______ days
   b) _______ days

53. Number of CHWs who work at the clinic?

54. How many days per week does each CHW work in the health facility?
   
   a) _______ days
   b) _______ days

55. What are the CHWs responsibilities while working at the facility?
   
   ___________________________________________________________________________

56. Is there someone responsible for cleaning the facility?  Y / N  (circle one)

57. Who is responsible for cleaning the facility?  __________________________

END OF SURVEY. NOTE ANY QUALITATIVE OBSERVATIONS HERE.
Semi-structured Interview Guide for Health Facility Staff

### ADMINISTRATIVE INFORMATION:

<table>
<thead>
<tr>
<th>Name of research assistant:</th>
<th>Facility Study ID:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research assistant signature:</td>
<td>--------------</td>
</tr>
<tr>
<td>Date of interview:</td>
<td>Interview start time:</td>
</tr>
<tr>
<td>______ / ______ / ______ (day / month / year)</td>
<td>_____ : _____ (hour) (min)</td>
</tr>
</tbody>
</table>

### QUANTITATIVE SECTION:

#### SUPERVISOR QUALIFICATIONS & EXPERIENCE WITH VHWs

<table>
<thead>
<tr>
<th>1. What is your position at this facility?</th>
<th>Doctor -------------------------------------------- 1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Medical officer ---------------------------------- 2</td>
</tr>
<tr>
<td></td>
<td>Medical assistant -------------------------------- 3</td>
</tr>
<tr>
<td></td>
<td>Maternal &amp; Child Health Head ------------------- 4</td>
</tr>
<tr>
<td></td>
<td>Reproductive &amp; Child Health Coordinator -- 5</td>
</tr>
<tr>
<td></td>
<td>Nurse --------------------------------------------- 6</td>
</tr>
<tr>
<td></td>
<td>Midwife ------------------------------------------- 7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. How many years experience do you have in this profession?</th>
<th>____________ years / months / weeks (circle one)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>3. How long have you worked in this role at THIS facility?</th>
<th>____________ years / months / weeks (circle one)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>4. Have you received any specialized training in the past 5 years?</th>
<th>1.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIRCLE ALL THAT APPLY.</td>
<td>a. community maternal and child health training (cMNCH)</td>
</tr>
<tr>
<td></td>
<td>b. infant and young child feeding (IYCF)</td>
</tr>
<tr>
<td></td>
<td>c. basic emergency obstetric care (bEMOC)</td>
</tr>
<tr>
<td></td>
<td>d. integrated management of child illness (IMCI)</td>
</tr>
</tbody>
</table>
I would like to ask your opinion about each village health worker you supervise. For each VHW, I will read several statements to you. After the statement is read, please tell me whether you “strongly agree”, “agree”, “disagree”, “strongly disagree”, or have “no opinion”. To begin, think about the first VHW you listed above. Your answers will not be shared with anyone outside of the research team. They will be kept private. Remind participant of which VHW they listed first. Once questions 7 – 29 are answered with this VHW in mind, repeat the questions for each VHW listed above (Use extra sheets attached). Be sure to number sheets according to the order in #6 above.

<table>
<thead>
<tr>
<th>VHW name</th>
<th>VHW’s village</th>
<th>VHW sex (M/F)</th>
<th>Number of meetings each month</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

8. He/she knows a lot about the health of mothers.
   - Strongly agree: 3
   - Agree: 2
   - Disagree: 1
   - Strongly Disagree: 0
   - No Opinion: 99

9. He/she contributes to the health of mothers and children in this community.
   - Strongly agree: 3
   - Agree: 2
   - Disagree: 1
   - Strongly Disagree: 0
   - No Opinion: 99
<table>
<thead>
<tr>
<th>Question</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>99</th>
</tr>
</thead>
<tbody>
<tr>
<td>10. The counselling and services offered by this village health worker have little impact on the health of mothers and children.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. He/she knows a lot about child health.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>12. He/she is not very good at diagnosing child illnesses.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>13. He/she gives good advice to clients.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>14. He/she does a good job of monitoring clients over time.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>15. He/she is dedicated and hard working.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>16. He/she demonstrates good communication skills with clients.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>17. He/she does not have many useful skills.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>18. He/she does not provide good solutions to their clients’ health problems.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>19. He/she has the proper tools to do their jobs well.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>20. He/she is compassionate towards clients.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>21. He/she does not have much time to spend with clients.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>22. He/she is respectful towards myself and other health facility staff.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>23. He/she is easy to get along with.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>24. He/she is reliable/dependable.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>25. I think he/she should be paid a salary.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>26. I believe he/she is honest.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>27. He/she is uncooperative.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>28. I think the Ministry of Health should officially recognize this village health worker.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>29. Overall, I have a good working relationship with him/her.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>30. Overall, I am satisfied with this village health worker’s performance.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Please feel free to answer the following questions honestly and accurately. We will keep your answers private. The questions have to do with the mothers and small children who come into the dispensary. We are interested in learning from you about women’s use of health services during pregnancy and childbirth.
10. In your experience, do women have difficulties accessing health services during pregnancy (i.e. antenatal care)?
   a. If yes, why do you think this is the case?
      • Probes:
        o Issues with distance to facility?
        o Issues with transport?
        o Issues with cost of services?
        o Any other barriers to access?

11. How far into pregnancy do most women seek antenatal care?
   a. Why?

12. What prevents women from going to the clinic early in pregnancy?

13. In the past 3 months, have more or less women come to the clinic to seek antenatal care?
   a. Why?

14. In the past 3 months, have more or less women come to the clinic to deliver babies?
   a. Why?

15. In the past 3 months, have there been any changes or upgrades in the infrastructure of the facility?

16. In the past 3 months, have there been any additional staff hired?
   a. If yes, what is their training? (e.g. nurse, midwife, etc.)

17. In the past 3 months, have there been any new services or programmes offered to women or children at this facility?

18. What are some of the challenges in providing good antenatal care to women in the clinic?
   a. Do you face any challenges in providing services to pregnant women?

19. Do men/husbands ever accompany women to the clinic during pregnancy?
   a. Why or why not?

20. Do you face any challenges when delivering babies here?
    • Supplies
    • Interactions with mamas
    • time

21. Where do most women in your community prefer to give birth?
   a. Why?
22. For most women in your community, who do they prefer to help with the delivery?  
   a. Why?

23. Who makes the decisions about where a woman should give birth? (e.g. the woman, her 
   husband, the mother in law, etc.)

24. Who makes decisions about who should attend the birth?

25. Do you think village health workers influence women’s health-seeking during pregnancy?  
   a. Why or why not?  
   b. If yes, how do they influence women’s health-seeking?

26. Do village health workers influence women’s decisions about where to give birth?  
   a. Why or why not?  
   b. If yes, how do they influence women’s health-seeking?

27. As a supervisor of village health workers, what does this supervision involve?

28. Can you explain how VHWs are supervised?

29. In your opinion, have more women come into the clinic for antenatal care since VHWs were 
   trained on the cMNCH program?

30. In your opinion, have more women come into the clinic to deliver babies since VHWs were 
   trained on the cMNCH program?

31. Has reporting by VHWs improved since they were trained on the cMNCH program?

32. Do you think the new tools that have been given to VHWs (e.g. paper-based registers, 
   counselling books, or mobile phones) have improved the quality of care provided by VHWs?  
   a. Can you explain why these have/have not been effective?  
   b. mHealth group only - probe:  
      i. Do you think it is a good thing that VHWs have been trained on cell phones?  
      ii. Why or why not?  
      iii. What is good about the phones?  
      iv. What is bad about the phones?

33. Do you think that providing new tools such as job aides would improve the quality of care 
   provided by VHWs?  
   a. What other kind of tools or job aides should VHWs have?
34. Do VHWs submit reports to you?
   a. How often do you receive these reports?
   b. Is there any difference in the timeliness or quality of reports you receive from the VHWs you supervise? Please explain.

35. Are the VHWs you supervise easy to work with?
   a. Why or why not?

36. Do you think the services that VHWs provide are important?
   a. Why or why not?

37. Is there anything else you’d like to tell us about the VHWs you supervise?
   a. Did we miss anything?

Do you have any questions for us?
The interview is now complete. Thank you for your time today. We appreciate your help with our research. Would you be interested in participating in future research activities for our study?
(Interviewer please check “yes” or “no” below):

__________ Yes  ___________ No

Interview end time:  ________ : ________
(hour) (min)
Semi-structured Interview: Community Health Workers

PART A: Administrative Information

<table>
<thead>
<tr>
<th>Name of research assistant:</th>
<th>Village ID:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research assistant signature:</td>
<td>------------</td>
</tr>
<tr>
<td>Date of interview:</td>
<td>VHW study ID:</td>
</tr>
<tr>
<td>__________ / _______ / _________</td>
<td>__________</td>
</tr>
<tr>
<td>(day / month / year)</td>
<td>VHW sex (circle one):</td>
</tr>
<tr>
<td></td>
<td>Male / Female</td>
</tr>
</tbody>
</table>

Script to be read aloud by interviewer:

***Please turn phone off for the interview to avoid interruptions***

A few months ago, you agreed to participate in a research study by the University of Toronto and World Vision. This study is called “Village Health Workers & Women’s Access to Maternal Health Services in Rural Tanzania”. As you will recall, you signed a consent form and completed a short survey for us.

I will briefly describe the study again, to remind you.

In this study, we want to learn more about what it is like to be a community health worker. We are interested in learning about the things that you like about your job, and the things that make your job difficult. We want to find out about World Vision’s trainings and new job aids and whether you find them useful. We would like to hear about your experiences, both good and bad. We also want to know about the health of pregnant women and mothers in your community. We would like to understand why, in your opinion, some women can/do access healthcare during pregnancy while others cannot/do not. Finally, we want to know whether the tools and trainings you have been given can help to improve women’s access to these health services.

This interview will include different types of questions. Some will require you to select answers from a list of options. Other questions will allow you to discuss your
experiences freely, providing as much detail as you would like to share. Please ask me questions at any time if you do not understand. The interview should take no longer than 90 minutes.

Can I begin the interview now? 

**Interview end time:** ____ ____ : ____ ____

**QUANTITATIVE SECTION:**

In the first section of the interview, I will ask you to choose only one answer to each question. You will answer the questions by showing me a card. Please answer by using the cards only. If you wish to elaborate on these answers, you will have an opportunity to do this later in the interview. Please do not explain your answers until I ask you to later.

**JOB SATISFACTION:**

The first few questions will ask how you feel about your job as a community health worker.

<table>
<thead>
<tr>
<th>Overall Job Satisfaction</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Think of your job in general. All in all, how often do the words below describe how you feel about your job?</strong></td>
</tr>
<tr>
<td>For each word or phrase below, please tell me whether this is always true, often true, sometimes true, never true, or you unsure.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Always</th>
<th>Mostly</th>
<th>Sometimes</th>
<th>Never</th>
<th>Unsure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pleasant</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>2. Bad</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>3. Great</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>4. Waste of time</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>5. Undesirable</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>6. Worthwhile</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>7. Worse than most other jobs</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>8. Acceptable</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>9. Better than most other jobs</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>10. Unpleasant</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>11. Makes me content</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>12. Inadequate</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>13. Excellent</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
</tbody>
</table>
Day to Day Duties:

Now think about your daily duties as a community health worker over the past 1 month only. How often would each of the following words or phrases describe your work?

For each word or phrase below, please tell me whether this is always true, often true, sometimes true, never true, or you are unsure.

<table>
<thead>
<tr>
<th></th>
<th>Always</th>
<th>Mostly</th>
<th>Sometimes</th>
<th>Never</th>
<th>Unsure</th>
</tr>
</thead>
<tbody>
<tr>
<td>14. Horrible</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>15. Enjoyable</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>16. Fascinating</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>17. Routine</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>18. Satisfying</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>19. Boring</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>20. Good</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>21. Gives sense of accomplishment</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>22. Respected</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>23. Exciting</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>24. Rewarding</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>25. Useful</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>26. Challenging</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>27. Simple</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>28. Repetitive</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>29. Creative</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>30. Dull</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>31. Uninteresting</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>32. Can see results</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>33. Uses my abilities</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
</tbody>
</table>

Supervision:
Now think of the kind of supervision you’ve received for your job in the past 1 month only. How often does each of the following words or phrases describe your supervision?

For each word or phrase below, please tell me whether this is always true, often true, sometimes true, never true, or you are unsure.

<table>
<thead>
<tr>
<th>Word or Phrase</th>
<th>Always</th>
<th>Often</th>
<th>Sometimes</th>
<th>Never</th>
<th>Unsure</th>
</tr>
</thead>
<tbody>
<tr>
<td>34. Supportive</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>35. Hard to please</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>36. Impolite</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>37. Praises good work</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>38. Sensitive</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>39. Influential</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>40. Up-to-date</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>41. Unkind</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>42. Discouraging</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>43. Motivating</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>44. Stubborn</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>45. Knows their job well</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>46. Intelligent</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>47. Absent</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>48. Available when needed</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
</tbody>
</table>

**PERCEIVED SELF-EFFICACY**

We want to know about how confident you are in your ability to do certain things in your job. Please remember that your answers will be kept private so you can feel free to answer honestly. Remember, we are not evaluating your work by asking these questions. We will not judge you based on your answers. We need you to tell us the reality so that we can help to improve your working situation in the future.
Now think about your job over the past 1 month only. For each statement I read aloud, please tell me whether you have “No Confidence”, “Low Confidence”, “Medium Confidence”, or “High Confidence” in your ability to do achieve the task.

<table>
<thead>
<tr>
<th>Statement</th>
<th>None</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
<th>Unsure</th>
</tr>
</thead>
<tbody>
<tr>
<td>49. Ability to solve problems that come up within my community</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>50. Ability to give opinions within a group setting</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>51. Ability to balance work with responsibilities at home</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>52. Ability to handle extra responsibilities on the job</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>53. Ability to stick to my daily schedule</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>54. Ability to problem-solve on the job</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>55. Ability to set goals for myself</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>56. Ability to reach the goals I set for myself</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>57. Ability to learn new skills and knowledge</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>58. Ability to positively impact my clients</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>59. Ability to travel to client homes when they need me</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>60. Ability to locate and follow up with clients</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>61. Ability to keep accurate records of my clients</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>62. Ability to handle emergency medical situations</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>63. Ability to refer clients to other health care providers</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>64. Ability to give advice or assistance to local mothers on maternal health issues</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>65. Ability to give advice or assistance to mothers on child health issues</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>66. Ability to answer questions about maternal nutrition</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>67. Ability to answer questions about child nutrition</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
</tbody>
</table>
QUALITATIVE SECTION:

Now I will ask you some questions that you can answer in more detail. Please feel free to give as much information as you like.

38. Can you describe what it is like to be a village health worker?
   a. What are your main duties as a village health worker?
   b. Can you describe to me what a regular workday is like?

   • If health education is mentioned – which topics?
   • How do you feel about your job?

39. Can you tell me some of the good things about your job as a village health worker? Why are these things good?

40. What motivates you to work as a village health worker? Why do you continue working?

41. What is your favourite thing about your job?

   • Why is this your favourite thing?
   • Can you explain further?

42. Can you describe a situation in which you felt really good about your job?

   • How did this situation make you feel?
   • Why did you feel this way?

43. Now, we all have bad days at work sometimes. All jobs have good things and bad things about them.
   a. What are some of the bad things about your job as a village health worker?
   b. What makes your job as a health worker difficult?

44. Can you describe a situation in which you felt bad about your job?

   • How did this situation make you feel?
   • Why did you feel this way?

45. Are there any things you’d like to change about your job?

46. Do you feel that your job is important?
a. Why or why not?

47. How does your community feel about your job/work?
   a. Are most members of your community supportive of you? Why or why not?
   b. Do they value the services you offer as a health worker?
   c. Why or why not?

48. How do husbands feel when you visit mothers and children at their households?
   a. Do they respect and value your work?
   b. Do they get involved in health education and counselling?
   c. Why do you think this is?

49. Do you believe you are well prepared to perform your duties as a health worker?
   a. What other trainings do you think would be helpful?

50. What kinds of job aids to you have?
   a. Are these tools helpful?
   b. What other aids would make your job easier?

*** For experimental group only, probe here about satisfaction with mobile phone and application:

- How do you feel about the cell phone?
- Is the device helping you? What does it help with the most?
- Is it easy to use?
- Have you run into any problems using the device?
- What do you like most about the mobile phone application?
- What do you like least?
- What would you change or add to the mobile phone application?
- How has using the device affected your relationship with clients?
- Do you interact with women differently, now that you have the phone?
- How do you think the women clients feel about the phone?
  - Do you think they’re happy with the phone?
  - Why or why not?
- Are your visits with clients longer or shorter, now that you have this phone?

51. Do you ever work at the health facility in your community?
   a. What tasks do you do while you’re there?

- Can you tell me more about that?
- How do you know that they are/are not supportive?
- How does this make you feel?
52. Do you feel supported by staff members at the **health facility** (i.e. nurses, medical assistants)?

53. Is there anything else you’d like to tell us about your job as a village health worker?

54. Do you work any other jobs? What is your household’s main source of income?

**The last set of questions has to do with the mothers and small children that you work with in your community. We are interested in learning from you about women’s use of health services during pregnancy and childbirth.**

55. In your community, do women go to clinic during pregnancy?
   a. In your experience, do women have difficulties accessing health services during pregnancy (i.e. antenatal care)?
   b. If yes, why do you think this is the case?

56. How far into pregnancy do most women seek antenatal care? Why?

57. What prevents women from seeking care early in pregnancy?

58. How good/bad is the quality of care provided to women in clinics? Can you describe the situation you have observed?
   a. For antenatal care
   b. For childbirth

59. Do men/husbands ever accompany women to the clinic during pregnancy?
   a. Why or why not?
60. Where do most women in your community prefer to give birth? Why?

61. For most women in your community, who do they prefer to have helping with the delivery? Why?

62. Who makes the decisions about where a woman should give birth?
   a. Who makes decisions about who should attend the birth?

63. Do village health workers influence women’s health seeking during pregnancy? How?

   *Probe:
   - What advice do you give women about this?

64. Do village health workers influence women’s decisions about where to give birth?

   *Probe:
   - What advice do you give women about this?

65. Have I missed anything? Is there anything else you’d like to tell me about the health of women and children in your community?

The interview is now complete. Thank you for your time today. We appreciate your help with our research. Would you be interested in participating in future research activities for our study? (Interviewer please check “yes” or “no” below):

_________ Yes  ___________ No

Interview end time:  ____ ____ : ____ ____
Follow-up Focus Group Discussion Guide (CHW Clients)

ADMINISTRATIVE INFORMATION:

<table>
<thead>
<tr>
<th>Name of FGD facilitator:</th>
<th>FGD facilitator signature:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Date of FGD:</th>
<th>Village ID:</th>
</tr>
</thead>
<tbody>
<tr>
<td>-------- / ------- / ----------</td>
<td>--------------</td>
</tr>
<tr>
<td>(day / month / year)</td>
<td>--------------</td>
</tr>
</tbody>
</table>

FGD start time:

____ ____ : ____ ____
(hour) (min)

Questions to guide discussion:

1. Like last time, we would like to learn more about your relationship with community health workers (CHWs) in your community.

   Last August, CHWs received maternal and child health training. Since then, has your relationship with them changed? (10 minutes)

   • If yes, how has the relationship changed?
   • Since the training, do they visit more or less often?
     o Why do you think this is?
   • Since the training, have the services provided by CHWs changed?
     o If yes, how so?
     o Have their services improved? Have you noticed a difference?

2. Since the last time we talked to you, have CHWs been visiting you at home?
   a. If yes, how often have they visited?
   b. How many times have each of you been visited by a CHW since our last meeting?
   c. Have you been visited by a CHW since you delivered the baby?
      i. How does this make you feel?
3. How knowledgeable are CHWs?

- Do CHWs have sufficient knowledge of pregnancy, childbirth, nutrition, and child health?
- Should they have more knowledge?

4. Are women in your community satisfied with the quality of care and services offered by CHWs?
   - Why or why not?
     - Are the CHWs kind?
     - Are the CHWs available when needed?
     - Are the CHWs helpful?
     - Do you prefer talking to the CHWs or the Nurses/facility staff about maternal health issues? Why?

5. What is the best thing about having CHWs in your community?
   a. What would happen if the CHWs stopped working in your village?

6. Do CHWs use any tools when they visit you at home?
   - Which tools do they use?
   - Do they always use these tools?

   **For experimental/mHealth group only:**
   *Probe specifically about satisfaction with mobile phone use...*

   - As you know, the CHWs have been using mobile phones to help with counselling women.
     - Have you noticed this when CHWs visit you?
     - How do you feel about this?

   - Last time, some of you said that you liked the phones. And some of you said you did not like that CHWs are using phones.
     - Do you still feel this way?
     - Has your opinion about the phones changed since the last time we met?
     - Why or why not?
• What is good about the mobile phones?
• What is bad about the mobile phones?
• Does everyone agree?

• What about confidentiality?
  • Do you think your health information is kept confidential by the phones?
  • Is privacy of the data better with the phones or with the hard copy registers/books?
  • Why do you feel this way?

• After the CHW collects your information with the phone, what happens to that data?
  • Where do you think the data goes?
  • Who can access this information?
  • How do you feel about this?
  • What if the phone is lost? What do you think will happen to the information?

• Are the services provided better or worse now that CHWs use mobile phones?
• Do the phones help you to learn about maternal and child health?
• Do they help the CHWs with their job? How?
• Does everyone agree?

7. Last time I was here we had a discussion about antenatal/clinic services during pregnancy. We talked about some of the challenges women face when going to the clinic during pregnancy. Would anyone like to discuss their experiences since our last meeting?

  • Treatment by nurses/facility staff – are they kind?
    • If nurses are unkind, does this discourage women from going to clinic?

  • How could ANC services be improved to encourage more women to go to clinic?

8. Last time I was here, you mentioned that pregnancies should be kept secret, and mamas should not tell others about their pregnancy.

  • Why do you think pregnancies should be kept secret?
  • What happens if you tell someone early in pregnancy?
  • Who told you about this? How did you learn about this?
    • PROBE about jealousy
      • What do you mean by Jealous? Please explain.
      • What makes others jealous?
Why would they be jealous if they have their own children already?
  • PROBE about witchcraft

9. Last time I was here we had a conversation about some of the challenges women face when delivering babies. Since the last time we met, some/most of you have delivered babies. Would anyone like to discuss their experience leading up to or during delivery?

   a. Where did you intend to deliver?
   b. Where did you actually deliver the most recent baby?
   c. Who assisted the delivery?
      i. Discuss TBAs vs. nurses/HCPs
   d. Why did you deliver at this location?
   e. What was the delivery experience like?
   f. Were you satisfied with the care/services provided?
   g. Did you encounter any challenges or complications during labour or delivery?
   h. If you have another baby, where will you prefer to deliver? Who would you like to assist you during delivery?

10. Of all the things we discussed today, what do you think is most important?
    a. Is there anything else we missed that you’d like to discuss?

Thank you for your time today. We really appreciate your help with this research.

FGD end time:

_____ : _____
(hour)   (min)
Household Survey for Women (CHW clients)

*note: this survey was reformatted and programmed to be administered on tablet devices*

**ADMINISTRATIVE INFORMATION:**

<table>
<thead>
<tr>
<th>Initials of research assistant:</th>
<th>Village ID:</th>
</tr>
</thead>
<tbody>
<tr>
<td>_______________________________</td>
<td>------------</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date of survey:</th>
<th>Participant ID:</th>
</tr>
</thead>
<tbody>
<tr>
<td>------- / ------ / --------</td>
<td>---------------</td>
</tr>
<tr>
<td>/       /       (day / month / year)</td>
<td></td>
</tr>
</tbody>
</table>

**SOCIODEMOGRAPHIC INFORMATION:**

During the survey, please ask for help if you do not understand a question. First I will ask some general questions about you and your household.

1. What is your date of birth?

<table>
<thead>
<tr>
<th>Date of birth:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>-------/-------/--------</td>
<td>day / month / year</td>
</tr>
</tbody>
</table>

2. What is the highest level of schooling that you’ve completed?

<table>
<thead>
<tr>
<th>Highest level of schooling</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>00</td>
</tr>
<tr>
<td>Non-formal</td>
<td>1</td>
</tr>
<tr>
<td>Primary 1-4</td>
<td>2</td>
</tr>
<tr>
<td>Primary 1-7</td>
<td>3</td>
</tr>
<tr>
<td>Secondary</td>
<td>4</td>
</tr>
<tr>
<td>Advanced secondary</td>
<td>5</td>
</tr>
<tr>
<td>College/University</td>
<td>99</td>
</tr>
</tbody>
</table>

3. What is the main source of drinking water for the household?

<table>
<thead>
<tr>
<th>Main source of drinking water</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Borehole or Piped water</td>
<td>1</td>
</tr>
<tr>
<td>Protected well/spring</td>
<td>2</td>
</tr>
<tr>
<td>Rainwater collection</td>
<td>3</td>
</tr>
<tr>
<td>Bottled water</td>
<td>4</td>
</tr>
<tr>
<td>Unprotected dug well/spring</td>
<td>5</td>
</tr>
<tr>
<td>Pond, river, stream</td>
<td>6</td>
</tr>
<tr>
<td>Don’t know</td>
<td>88</td>
</tr>
<tr>
<td>Other</td>
<td>99</td>
</tr>
</tbody>
</table>

(specify)
### HEALTH CARE DELIVERY BY COMMUNITY HEALTH WORKERS

I would like to ask your opinion about community health workers’ care and services. I will read several statements to you. After the statement is read, please tell me whether you “strongly agree”, “agree”, “disagree”, or “strongly disagree”.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
<th>Unsure</th>
</tr>
</thead>
<tbody>
<tr>
<td>8. Community health workers know a lot about the health of mothers.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>99</td>
</tr>
<tr>
<td>9. Community health workers know a lot about child health.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>99</td>
</tr>
<tr>
<td>10. Community health workers are not very good at diagnosing child illnesses.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>11. I trust the health advice given by community health workers</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>99</td>
</tr>
<tr>
<td>12. Community health workers are good at monitoring their clients over time.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>99</td>
</tr>
<tr>
<td>13. Community health workers have a lot of useful skills.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>99</td>
</tr>
<tr>
<td>14. Community health workers do not provide good solutions to my family’s health problems.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>15. Community health workers have the proper tools to take care of mothers and young children.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
</tbody>
</table>

**INTERPERSONAL ASPECTS OF CARE**

Your answers to the following statements will help me to learn more about your relationship with community health workers in your area. Again, after the statement is read, please tell me whether you “strongly agree”, “agree”, “disagree”, or “strongly disagree”.

<table>
<thead>
<tr>
<th></th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
<th>Unsure</th>
</tr>
</thead>
<tbody>
<tr>
<td>16. Community health workers are compassionate towards myself and my children.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>99</td>
</tr>
<tr>
<td>17. Community health workers are disrespectful towards myself and my children.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>18. Community health workers do not have much time to spend with the women and children they care for.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
</tr>
<tr>
<td>19. I find it easy to talk to community health workers.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>99</td>
</tr>
<tr>
<td>20. I believe community health workers are honest.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>99</td>
</tr>
<tr>
<td>21. Overall, I am satisfied with the care provided to my family by community health workers.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>99</td>
</tr>
</tbody>
</table>

Now I will ask you some questions about the closest health facility and the staff who work there. Again, after the statement is read, please tell me whether you “strongly agree”, “agree”, “disagree”, or “strongly disagree”.

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>11. I trust the health advice given by community health workers</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>12. Community health workers are good at monitoring their clients over time.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>13. Community health workers have a lot of useful skills.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>14. Community health workers do not provide good solutions to my family’s health problems.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>15. Community health workers have the proper tools to take care of mothers and young children.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Strongly Agree</td>
<td>Agree</td>
<td>Disagree</td>
<td>Strongly Disagree</td>
<td>Unsure</td>
<td></td>
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<td>---</td>
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<td>-------</td>
<td>----------</td>
<td>-------------------</td>
<td>-------</td>
<td></td>
</tr>
<tr>
<td>22. Health facility staffs are compassionate towards my children and myself.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>23. Health facility staffs are disrespectful towards my children and myself.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>24. Health facility staffs do not have much time to spend with the women and children they care for.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>25. I find it easy to talk to health facility staff.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>26. I trust the health/medical advice provided by health facility staff.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>27. Health facility staff are knowledgeable about maternal and child health.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>28. Health facility staff are unkind to patients.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>29. The health facility is always clean and well maintained.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>30. The health facility has proper medical equipment.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>31. The health facility often runs out of medication and supplies.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>32. The health facility is well staffed.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>33. Line-ups at the health facility are too long.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>99</td>
<td></td>
</tr>
<tr>
<td>34. Overall, I am satisfied with the care provided to my family by health facility staff.</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>99</td>
<td></td>
</tr>
</tbody>
</table>

**MOST RECENT PREGNANCY & DELIVERY**

The next questions are about your most recent pregnancy and delivery.

*Note to interviewer:*

Where applicable, please confirm the following information by asking to see the participant’s clinic card.

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>35. Did you deliver your most recent baby in a health facility?</td>
<td>YES ..........</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>NO ..........</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>36. If yes, in what type of facility did you deliver this baby?</td>
<td>Dispensary</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hospital</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Health Centre</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>37. If yes, was this the nearest health facility to your home?</td>
<td>YES ..........</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td>Yes</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>-------------</td>
<td>-------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>38. If you did not give birth in a health facility, please tell us where you delivered.</td>
<td>At home</td>
<td>On the way to facility</td>
<td>Other</td>
<td>99</td>
</tr>
<tr>
<td>39. If you did not give birth in a health facility, can you tell us why?</td>
<td>I prefer to deliver at home</td>
<td>Health facility too far away</td>
<td>Health facility too expensive</td>
<td>Husband/partner insisted</td>
</tr>
<tr>
<td>40. Did you receive postnatal care (PNC) at a health facility within 2-3 days after childbirth? (*check RCH1 card)</td>
<td>YES</td>
<td>NO</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>41. How many antenatal care (ANC) clinic visits at a health facility did you attend during your most recent pregnancy? (*check RCH4 clinic card)</td>
<td>One</td>
<td>Two</td>
<td>Three</td>
<td>Four</td>
</tr>
<tr>
<td>42. How many months pregnant were you when you went for the first ANC clinic visit? (*check RCH4 clinic card)</td>
<td>Number of months</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>43. When you were pregnant with this child, did you receive or buy any tablets to increase the blood (iron)? (show tablet)</td>
<td>YES</td>
<td>NO</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>44. I’m not interested in knowing your results, but did you receive HIV testing during this pregnancy?</td>
<td>YES</td>
<td>NO</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>45. I’m not interested in knowing your results, but did your partner/husband receive HIV</td>
<td>YES</td>
<td>NO</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Question</td>
<td>Options</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>-------------------------------------------------------------------------</td>
<td>--------------------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>46. Did you take de-worming medication during pregnancy?</td>
<td>YES ................................ 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>NO .................................. 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>47. Do you have insecticide treated mosquito nets at home?</td>
<td>YES ................................ 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>NO .................................. 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>48. If yes, who usually sleeps under the net(s)?</td>
<td>My husband only ........................ 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Myself only ................................ 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>My child(ren) only ........................ 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>My husband and myself only .............. 4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Myself and my children only ............ 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>My husband, myself, and my child(ren) 6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>49. During your last pregnancy, how often did you sleep under the net?</td>
<td>Every night ................................ 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Most nights ................................ 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Some nights ................................ 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Never/not at all ........................ 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50. Did you sleep under the net last night?</td>
<td>YES ................................ 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>NO .................................. 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>51. How many doses of malaria prophylaxis (IPT) did you receive during pregnancy?</td>
<td>ONE .......................... 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TWO ............................. 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>NONE ............................ 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>52. Were you ever referred to a health facility by a CHW during this pregnancy?</td>
<td>YES ................................ 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>NO .................................. 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>53. If you were referred by a CHW, did you go to the clinic?</td>
<td>YES ................................ 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>NO .................................. 2</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>54. If no, why not?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>55. Did your husband/partner accompany you to any ANC appointments?</td>
<td>YES ................................ 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>NO .................................. 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>56. If yes, how many?</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>57. Did your husband/partner accompany you during your last delivery?</td>
<td>YES ................................ 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>NO .................................. 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td>Options</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>----------</td>
<td>---------</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>58. Did you make a birth plan before delivery?</td>
<td>YES …………</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>NO …………</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>59. If yes, who helped you to develop the birth plan?</td>
<td>Health Facility Staff --------</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Community Health Worker ------</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TBA ----------------------------</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family member ------------------</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other: _____________________ (specify)</td>
<td>99</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60. Where did you plan to deliver?</td>
<td>At home --------------------------</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dispensary ----------------------</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hospital ------------------------</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relative’s home -----------------</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other: ______________________ (specify)</td>
<td>99</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>61. Was this baby given an oral polio vaccine at birth? (*check RCH1 card)</td>
<td>YES …………</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NO …………</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>62. Was the baby given a BCG vaccination within the first week after birth? (*check RCH1 card)</td>
<td>YES …………</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NO …………</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>63. Have you ever breastfed this baby?</td>
<td>YES …………</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NO …………</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*If no, skip to Q?</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>64. How long after birth was the baby put to the breast?</td>
<td># of hours</td>
<td>____</td>
<td></td>
<td></td>
</tr>
<tr>
<td># of days</td>
<td>____</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If less than 1 hour, record “0” hours. If less than 24 hours, record hours. Otherwise, record days.</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>65. Were any other liquids or foods given to the baby during the first week after birth?</td>
<td>YES …………</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NO …………</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If yes, please list:</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Question</td>
<td>Answer Options</td>
<td></td>
<td></td>
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<tr>
<td>-------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>66. Are you currently breastfeeding this baby?</td>
<td>YES ……….. NO ……….. 1 2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| 67. Now I would like to ask you about liquids or foods *(child’s name)* had yesterday during the day or at night. Did *(child’s name)* drink or eat: | a. Breast milk …………………………………… Y N  
  b. Plain water …………………………………… Y N  
  c. Infant formula …………………………………… Y N  
  d. Any fortified, commercially available infant and young child food (e.g. give local name/brand) …. Y N  
  e. Any (other) porridge or gruel ………………… Y N |
* For each option, circle Y or N |
| 68. We’d like to know about your awareness of healthy nutrition practices during pregnancy and breastfeeding. Could you please name any healthy practices that you’re aware of? | 1. Eat a balanced diet (protein, carbohydrates, fruits, vegetables and fats)  
  2. Prepare in a hygienic environment  
  3. Eat three meals a day and snacks in between  
  4. Eat iron-rich foods (e.g. meat, fish, vegetables)  
  5. Take iron/folic acid pills during pregnancy and up to 40 days after delivery  
  6. Use iodized salt  
  7. Do not overcook vegetables  
  8. Do not eat things that are not food (e.g. sand/charcoal/ash)  
  9. Does not know any of the above |
| 69. We’d like to know about your awareness of danger signs during pregnancy. Could you please name any danger signs that you’re aware of? | 1. Difficulty breathing  
  2. Fatigue/tiredness  
  3. Vaginal bleeding  
  4. Baby is not moving much or stopped moving completely  
  5. Loss of consciousness or convulsions  
  6. Headache or blurred vision  
  7. Early labour pain before 9 months  
  8. Liquid leaking from vagina (discharge)  
  9. Signs of malaria (feeling cold, fever, vomiting)  
  10. High Blood Pressure  
  11. Swelling of face and arms  
  12. Does not know any of the above |
| 70. We’d like to know about your awareness of danger signs soon after delivery up to 42 days. Could you please name any danger signs that you’re aware of? | 1. Excessive vaginal bleeding  
  2. Severe abdominal pain or vaginal pain  
  3. High fever or chills  
  4. Fistula  
  5. Loss of consciousness or convulsions (eclampsia)  
  6. Headache or blurred vision  
  7. Swollen breasts or cracked nipples  
  8. Disoriented/abnormal behaviour  
  9. Liquid leaking from vagina (discharge)  
  10. Severe pain in leg muscles |
11. Does not know any of the above

<table>
<thead>
<tr>
<th>Question</th>
<th>YES</th>
<th>NO</th>
<th>UNSURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>71. In the past, did you ever experience any difficulties or complications while giving birth (with any of your children)? *If no, skip to next section.</td>
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<tr>
<td>72. If yes, what complications did you experience? SELECT all complications mentioned:</td>
<td></td>
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</tr>
<tr>
<td>Hemmoraging (excessive bleeding)</td>
<td></td>
<td></td>
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<tr>
<td>Cord around the neck</td>
<td></td>
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<tr>
<td>Prolonged labour</td>
<td></td>
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<tr>
<td>Eclampsia</td>
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<tr>
<td>High Blood Pressure</td>
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<tr>
<td>Retained placenta</td>
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<tr>
<td>Does not know/remember</td>
<td></td>
<td></td>
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<tr>
<td>Other (Please specify)</td>
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</tbody>
</table>

73. Who do you prefer to assist you during delivery? 

<table>
<thead>
<tr>
<th>Choice</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>99</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doctor</td>
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<td></td>
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<tr>
<td>Nurse</td>
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<tr>
<td>Medical Officer</td>
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</tr>
<tr>
<td>Medical Assistant</td>
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<td></td>
</tr>
<tr>
<td>Nursing/Medical Student</td>
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<tr>
<td>Traditional Birth Attendant</td>
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<tr>
<td>Family member</td>
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<tr>
<td>Other</td>
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<td></td>
<td></td>
<td></td>
<td>99</td>
</tr>
</tbody>
</table>

74. Where is your preferred place of delivery? 

<table>
<thead>
<tr>
<th>Place</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>99</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dispensary</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health Centre</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Hospital</td>
<td></td>
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</tr>
<tr>
<td>Other</td>
<td></td>
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<td>99</td>
</tr>
</tbody>
</table>

PREGNANCY AND CHILDBIRTH AND HISTORY
Now I will ask some questions about your pregnancy and childbirth history.
75. How many children do you have?  

<table>
<thead>
<tr>
<th>Child</th>
<th>a. Child’s date of birth (day / month / year)</th>
<th>b. Place of Delivery</th>
<th>c. Who assisted delivery?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Home = 1</td>
<td>Doctor = 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dispensary = 2</td>
<td>Nurse = 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Health Centre = 3</td>
<td>Medical Officer = 3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hospital = 4</td>
<td>Medical Assistant = 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In transit = 5</td>
<td>TBA = 5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other = (specify)</td>
<td>Family member = 6</td>
</tr>
</tbody>
</table>

76. For each of the children listed above (starting with the youngest), please tell me the following:  

a. their date of birth  
b. where they were delivered  
c. who assisted the mother at delivery

<p>| | | | | | | | | | |</p>
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>1</td>
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<td>9</td>
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</tr>
</tbody>
</table>

77. You mentioned that you would prefer to deliver at _______ but I noticed that most of your children were delivered _______. Could you tell us why this might be so?  

TO BE ASKED FOR EACH CHILD WHERE THERE IS DISCREPANCY.

<p>| | | | | | | | | | |</p>
<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Health facility too far away ----</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Preferred option too expensive -----</td>
<td>2</td>
<td></td>
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<tr>
<td></td>
<td>Husband/partner insisted --------</td>
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<tr>
<td></td>
<td>Mother in-law insisted --------</td>
<td>4</td>
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<td></td>
<td>No transportation ---------------</td>
<td>5</td>
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<td></td>
<td>Other _________________________</td>
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</tr>
</tbody>
</table>

78. Did a community health worker ever visit you at home during your most recent pregnancy?  

<p>| | | | | | | | | | |</p>
<table>
<thead>
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</thead>
<tbody>
<tr>
<td>YES</td>
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<td>NO</td>
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</tbody>
</table>

79. If yes, how many times did a community health worker visit you during your most recent pregnancy?  

<p>| | | | | | | | | | |</p>
<table>
<thead>
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</thead>
<tbody>
<tr>
<td>Once</td>
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<td>Twice</td>
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<tr>
<td>Three times</td>
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<tr>
<td>Four times</td>
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<td>4</td>
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</tr>
<tr>
<td>Question</td>
<td>Response Options</td>
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<tr>
<td>-------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>80. If yes, did the CHW use a cell phone as a tool when they visited you during your most recent pregnancy?</td>
<td>YES .............. 1</td>
<td></td>
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<td></td>
<td>NO .............. 2</td>
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</tr>
<tr>
<td>81. If yes, did the CHW use a photo flipbook when they visited you during your most recent pregnancy?</td>
<td>YES .............. 1</td>
<td></td>
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<td>NO .............. 2</td>
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<tr>
<td></td>
<td>(SHOW PHOTO FLIPBOOK)</td>
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<tr>
<td>82. Has a community health worker visited you since the birth of your most recent baby?</td>
<td>YES .............. 1</td>
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<td>NO .............. 2</td>
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<tr>
<td>83. If yes, how many times did a community health worker visit you?</td>
<td>Once ------------------------ 1</td>
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<td>Twice ----------------------- 2</td>
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<td>Three times ------------- 3</td>
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<td>Four times -------------- 4</td>
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<td></td>
<td>More than four times ---- 5</td>
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</tr>
<tr>
<td>84. If yes, did the CHW use a cell phone as a tool when they visited you during your most recent pregnancy?</td>
<td>YES .............. 1</td>
<td></td>
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<tr>
<td></td>
<td>NO .............. 2</td>
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</tr>
<tr>
<td>85. If yes, did the CHW use a photo flipbook when they visited you during your most recent pregnancy?</td>
<td>YES .............. 1</td>
<td></td>
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<tr>
<td></td>
<td>NO .............. 2</td>
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<td>(SHOW PHOTO FLIPBOOK)</td>
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</tr>
</tbody>
</table>

This is the end of the survey. Is there anything you would like to ask me?

Would you be interested in participating in future research activities?

**Circle one:** YES / NO

Thank you for your time. We appreciate your help with our research.
Appendix C
Secondary Quantitative Results

Significant positive results were observed for a number of secondary outcomes, summarized in Table 1 below. Many of these indicators (e.g. vaccinations administered at birth) serve as proxies for facility-based delivery (FBD), and the higher rates of perinatal and postnatal service delivery reported among women in experimental group provides indirect evidence of the validity of the main outcome results.
Table 1. Summary of Unadjusted Secondary Outcome Results*

<table>
<thead>
<tr>
<th>Event</th>
<th>Total (N,%</th>
<th>SP+ (N,%</th>
<th>Control (N,%</th>
<th>p-value**</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Statistically significant outcomes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Received postnatal check-up within 1 week after delivery</td>
<td>306 53.5</td>
<td>175 57.6</td>
<td>131 48.9</td>
<td>0.04</td>
</tr>
<tr>
<td>Infant received polio vaccination</td>
<td>355 62.1</td>
<td>202 66.4</td>
<td>153 57.1</td>
<td>0.02</td>
</tr>
<tr>
<td>Infant received BCG vaccination</td>
<td>294 51.4</td>
<td>171 56.3</td>
<td>123 45.9</td>
<td>0.03</td>
</tr>
<tr>
<td>Was visited by a CHW since most recent delivery</td>
<td>449 78.5</td>
<td>246 80.9</td>
<td>203 75.7</td>
<td>0.01</td>
</tr>
<tr>
<td>Has an insecticide-treated bed net in the home</td>
<td>516 90.2</td>
<td>282 92.8</td>
<td>234 87.3</td>
<td>0.03</td>
</tr>
<tr>
<td><strong>Non-significant outcomes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Developed a birth plan in advance</td>
<td>506 88.5</td>
<td>268 88.2</td>
<td>238 88.8</td>
<td>0.81</td>
</tr>
<tr>
<td>Was visited by a CHW during most recent pregnancy</td>
<td>506 88.5</td>
<td>279 91.8</td>
<td>227 84.7</td>
<td>0.13</td>
</tr>
<tr>
<td>Received deworming medication during pregnancy</td>
<td>467 81.6</td>
<td>245 80.6</td>
<td>222 82.8</td>
<td>0.76</td>
</tr>
<tr>
<td>Received HIV test during pregnancy</td>
<td>542 94.8</td>
<td>289 95.1</td>
<td>253 94.4</td>
<td>0.72</td>
</tr>
<tr>
<td>Received 2 IPT doses during pregnancy</td>
<td>384 67.1</td>
<td>198 65.1</td>
<td>186 69.4</td>
<td>0.65</td>
</tr>
<tr>
<td>Received iron folate tablets during pregnancy</td>
<td>532 93</td>
<td>280 92.1</td>
<td>252 94</td>
<td>0.37</td>
</tr>
<tr>
<td>Partner received HIV test during pregnancy</td>
<td>460 80.4</td>
<td>245 80.6</td>
<td>215 80.2</td>
<td>0.63</td>
</tr>
<tr>
<td>Partner attended at least 1 ANC visit</td>
<td>450 78.7</td>
<td>233 76.6</td>
<td>217 81</td>
<td>0.21</td>
</tr>
<tr>
<td>Initiated breastfeeding within 1 hour after birth</td>
<td>468 81.8</td>
<td>250 82.2</td>
<td>218 81.3</td>
<td>0.78</td>
</tr>
<tr>
<td>BF exclusively during 1st week after birth</td>
<td>561 98.1</td>
<td>299 98.4</td>
<td>262 97.8</td>
<td>0.61</td>
</tr>
</tbody>
</table>

* self-reported by women during household survey
** Significance assessed by Chi-square tests for proportions
There were no significant differences between study groups for awareness of healthy nutrition practices during pregnancy. Participants in the control group had slightly higher awareness of danger signs during pregnancy and childbirth (Table 2).

**Table 2. Unadjusted scores: women’s awareness of healthy nutrition practices and danger signs**

<table>
<thead>
<tr>
<th>Number of correct practices listed (mean, SE)</th>
<th>Total</th>
<th>SP+</th>
<th>Control</th>
<th>p-value**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Awareness of healthy nutrition practices during pregnancy &amp; breastfeeding</td>
<td>1.3 0.1</td>
<td>1.4 0.06</td>
<td>1.3 0.07</td>
<td>0.48</td>
</tr>
<tr>
<td>Awareness of danger signs during pregnancy</td>
<td>1.4 0.06</td>
<td>1.3 0.07</td>
<td>1.5 0.08</td>
<td>0.06</td>
</tr>
<tr>
<td>Awareness of danger signs during childbirth</td>
<td>1.2 0.05</td>
<td>1.2 0.05</td>
<td>1.4 0.08</td>
<td>0.05</td>
</tr>
</tbody>
</table>

* self-reported by women during household survey
** Significance assessed by Chi-square tests for proportions
Appendix D
CHW Motivators and Deterrents

Figure 1. Motivators and Deterrents reported by volunteer CHWs.

Following the approach used by Greenspan et al (2013), I labeled challenges and opportunities as motivators and deterrents and categorized these factors as either intrinsic or extrinsic. CHW in both study arms were motivated by a number of intrinsic and extrinsic factors, despite experiencing with persistent challenges in their work.
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<thead>
<tr>
<th>Deterring factors</th>
<th>Quote(s</th>
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<tbody>
<tr>
<td>Tensions between duty, morality and the desire to be recognized</td>
<td>“I am a CHW but my children may be malnourished because I fail to do my personal activities at home. I deal mostly with the community and fail to meet the needs of my house. If we could have a salary it will be good… I feel like I am weak because I fail to attend some of my personal activities due to this job, but I feel good because I know I am saving people’s lives. I feel like that because I am changing my community from a bad to good situation. I will never lose hope but we need the government to think about us.”</td>
<td>C45</td>
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| Lack of village level support                                                    | “We the community health workers, we are treated like brooms. We are only needed when there is a need to sweep out the dirt, and then left behind after the sweeping is done… It (has been) 21 years and they have told us that same story, so we are unsure if they will ever improve things”  
“The village government is supposed to support us. They are supposed to pay for our bus fees, but they don’t! If we want to travel to the seminar, they don’t give us the money, even though they said they would. They said previously that every health worker should be paid each month. This hasn’t been implemented. There is no cooperation.”  
“They want the people to remain as fools, because if they get the education, the leaders may lose their power”  
“The village itself (village leaders) have never appreciates us, not even a single day, and sometimes they even discourage us. Most of the time they do not cooperate with us. If there is a meeting and we want them to include us on their agenda to educate the community, they do not call the meeting. The leaders feel disturbed by us. We need the leaders to recognize us by praising us or giving us anything, like money” | C60    |
|                                                                                 |                                                                                                                                                                                                        | C38    |
|                                                                                 |                                                                                                                                                                                                        | C28    |
|                                                                                 |                                                                                                                                                                                                        | C10    |
| Heavy workload                                                                  | “I feel good although the work is very hard; sometimes I have to stop my personal activities that allow me to get food at home, and this delays my progress in achieving development. That is why many of the community health workers drop this work and do other personal business instead. It’s so they can get something to eat because we get nothing from this work.” | C18    |
For example in our village we were 24 health workers (previously) but now we are only 2.”

“The work responsibilities are increasing so much. You are told to do cleaning, while your work is to take measurements. You may also be told to open clinic for the pregnant women, which is not really my job. Also to open cards for the pregnant women and premature children […] I am feeling angry because those tasks are outside of my duties. They add tasks to my workload that are required to be attended by other people who are professionals for these tasks.”

“The whole day you might visit one or two people, that’s why everyone has to go out because you are walking by foot. Even if you are using a bicycle you might find that often you have things to do at home so you don’t go out every day. The biggest obstacle is the transportation.”

“The phone has not changed the distance from one household to another. If I used twenty minutes before the phone I still use them even now, so the phone has not changed this, we still need means of transport.

| Lack of salary (financial incentives) | “In this area, I think things are changing and life has become so hard, so you can’t expect us to waste all our time walking to reach the households for the whole week, without any payment. How do they expect us to earn the income to support our families? It’s a volunteer job I know that, but in reality there should be some support to help us live normal lives like other citizens” |

| Lack of salary (financial incentives) | “The salary should come from the government. We were told it is supposed to be provided by the village government but they are not close to us… You may be promised that if you weigh children at the clinic you will be given money… you can even do that work for a whole month, then you realize it was a fake promise.” |

| Lack of salary (financial incentives) | “If we educate our communities but we have nothing (of value) they will look down on us. They see you as if you are poor and underdeveloped… so how will you educate people while you're just as poor as them?” |

| Lack of salary (financial incentives) | “The costs of working as a CHW are your own feet, and your blood [nervous laughter] because you’re not given anything for this work” |
“We get tired and the community thinks that we are paid. This happens when they ask us to go (to visit them) and we refuse… they start complaining that we are not working and instead we just use their money for nothing.”

“In order to have motivation to work, income is needed. This will motivate me to work even harder and concentrate on the job. As I explained before, I have other responsibilities at home... sometimes problems occur that are unplanned. For example, when someone is sick or dies or your neighbors have a ceremony you should attend... and also you are supposed to find some money for your family.”

“Maybe we should be given even just a little. I was saying that we started volunteering since long ago so why shouldn’t they give us a position for example now there are no health officers in the ward and they don’t require much education to be a health officer, so the government should at least think about us.”

“Things that I would like to change at my job, like transport, we don’t have transport. The other thing I would like to be given is bags for carrying job tools, an umbrella, gumboots and a raincoat during rainy season. Also I would like the government to recognize us by giving us a salary.”

“I feel desperate in this situation, but I have been told that I shouldn’t give up. That one day I will get wages and transport”

“I feel good sometimes. But this work becomes hard sometimes, due to a lack of transport. Therefore we use so much time to walk, we do not have a bag for carrying our job tools, we do not have an umbrella to use during rainy season. Also during rain season I fail to do my farm activities because this work needs you to be like the teacher so you fail to do other home activities.”

"Other tools like an umbrella, a raincoat, boots for the rainy season because of water and mud. A motorcycle would be better since the community is calling on us often because they know we are helping. So, a motor bicycle would facilitate our work as sometimes we visit very far places. The bicycles are tiresome.”
| Behaviour change too slow | “I think the government or people who see the importance of what we are doing should help us get all the important things that we need to accomplish our goals. The society is really changing through the work that we are doing so if we can be more supported it will help the society to change very fast, so I think people should see this and give us a hand.”

| C39 | “There are some households which are still reluctant to follow our advice, you might find every time you teach them they say they will change but when you go back you find them repeating the same mistake, so as a teacher you must get tired and feel bad about it, because you use a lot of effort in teaching them.”

| C39 | }
<table>
<thead>
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<th>Motivating factors</th>
<th>Quote(s)</th>
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| Religion, sense of moral duty, altruism | “I feel good about my job because I have sacrificed myself to be a community health worker to provide services to the people.”  
“A volunteer must be patient. You have to pray to God as it has been said in the bible: don’t complain so much, because God has his own plans that you cannot know... So maybe I won’t get any payment now, but the rewards could be passed down to my children one day… so it forces me to continue working… They used to say that a patient person will be given sweet rewards. That is why I say the sweetness is not necessary for me to take; maybe it will be passed thorough my child, and that is the fruit that I will take”  
“Sometimes the rumours make me feel bad, people talking. Where there are many people there are also many things (means information, a Swahili saying)... But these are just words that people utter. I don’t care about the words; I always go on with my job... Although they provoke us, we feel bad but still we laugh along with them and the following days again you go to follow up… To some extent I feel bad, but you just count these as challenges. You can’t live in a world without challenges; you can’t live every day like that. You may be feeling bad but you forgive right away and forget. Even Jesus was insulted but he forgave his people.”  
“I felt so good when I was selected! I can say that it was the call of God that chose me. For sure when I was selected I wasn’t even around (the village) at that time, and I was just given a letter to go… I was told you are supposed to be a community health worker of the village and then I thanked God! I said ‘Thank you God because you are the one who selected me’”  
“To me, my work is good because even in the bible God said he may select you to do this work (volunteering). It is God who selected me to do this work (Laughing). You may find that a person is very happy with this work even though they don’t have an allowance... I feel so happy because I...” | C60    |
|                                    | C41                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |        |
|                                    | C10                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |        |
|                                    | C02                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |        |
|                                    | C02                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |        |
see myself as one who is among those who work for God.”
“Something is very hard and we do it for the good of humanity […] We don’t get paid but we do it for the benefit of the nation”

| Pride in being selected; community trust and relationship building | “For me to be trusted by society, well it’s the people themselves who can tell if a person is fit for the job, so when they decided to choose me (to be a CHW) I really appreciated this. I feel good when I go to teach the community, I can see that the village members trust me.”

“I like this because if people are talkative to me it will be easy to teach them and for them to understand me. If you go to the foreign place and the people do not welcome you, you will not feel good. But when I provide services to my (own) people, a larger percent show love to me. I like to be close with the community in order to know all the problems that might happen.”

“I feel very good, it’s so good. I can tell you that for the time being people have gotten used to me very much. I have become familiar to people. I am not praising myself for that, but people really love me, every time I meet them they are cheering and laughing while saying ‘come, come explain to us!’… It feels good when they [clients] see me, and they become happy, and if they have another thing to do, I just greet them. They stop and listen to me. And they welcome me, even when the man (husband/father) is around, he comes and listens to me also […] Yes they are happy and they make me feel very good. When I visit them they just start laughing before I start to teach them. Before I even start talking, they are laughing.” |

| Personal benefits; benefits for family members | “When you are volunteering you must be patient. They used to say that a patient person will be given sweet rewards. That is why I say the sweetness is not necessary for me to take; maybe it will be passed thorough my child, and that is the fruit that I will take.”

“Another thing which makes me thankful is that I have acquired more education. Now I have some knowledge and although it is not so much, I have started to understand and to educate my fellow community members.” |
“Yes, I feel good to be a community health worker because personally, I found myself in good health status… and to educate the community, including my own family – well now we have an understanding; we understand more about health.

“What motivates me to go on working in the village, first is education. Education has changed me and also my family because even my own son… he is healthy and now he has finished his secondary studies and he’s still healthy and stronger than other children who left school due to early pregnancies”.

| Witnessing healthy behaviour change, community development | “I have witnessed a good situation. There was a woman I went to educate… she was nine months pregnant. I went to educate her about how to plan and prepare for delivery, and tell her about all the things she’s supposed to go with. When I left that evening they had to find transportation to send her to the health facility. I didn’t know when I was talking to her that she was experiencing labour pains (already). So they took her to the hospital… later on they called and told me the woman you were talking to yesterday has delivered safely. I went in the morning to see her and the family. They were so happy.”

‘I become happy when I see the good results for children and women. If you do the work without the good result you cannot be happy with the work […] Like this woman who delay going to the clinic, if this happens the children do not receive the vaccines so it becomes not so good. Because nowadays we want to move forward instead of moving backwards again.”

“I continue to work as a community health worker in the village is because I want to help my fellows to move away from bad traditions and norms, in order to be up to date on health issues. [For example] some don’t want to take their children to clinic because they don’t know its benefits.”

Yes, my work is so important because the community needs to be up to date, and it’s the time of improved health. We want good health of people to stay longer and be sustainable. Before people were not aware about being | C01
| C62
| C21
| C22
| C58
| C10
healthy, but then later our nation and the world recognized that without good health there is more deaths. So the work is so important in order to improve health and (ensure) good livelihoods.”

| Supportive supervision | “I’m feeling great because of the supervisors we have. We get along with them, and they are the ones who train us. They are encouraging us to do the job and they are following up with us nicely […] Supervisors such as world vision organization and the health workers at the dispensary.” |

**Key points on CHW motivation:**

- CHWs grapple with complex moral dilemmas, and must negotiate tradeoffs between duty, religion, morality, and personal/family responsibilities

- Altruistic motivation does not preclude a desire for fair remuneration and recognition

- In an era of emphasis on “patient-centered care” within the global health community, a focus on the well being of frontline health workers must not be an afterthought.

**An excerpt from my field notes reflecting on the issue of CHW volunteerism:**

By not compensating CHWs, government authorities and NGOs may be missing a critical opportunity to make drastic gains in MNCH. It is clear that despite intrinsic sources of motivation, many CHWs are not working to their full potential (particularly those in the control group). CHWs represent an incredible missed opportunity – they are already fairly well trained, and for the most part they are extremely hard working and motivated, despite having to deal with overwhelming challenges and set-backs on a daily basis. They persevere and have a genuine concern for improving their communities, but the reality is that with no financial compensation, and an unrealistic workload, CHWs themselves are pushed further and further into poverty. They have little extra time to work on household income-generating activities, and their own families become neglected. The irony of this is that CHWs are meant to promote
healthy communities and indirectly contribute to poverty reduction by setting examples for their community members. How can they set a positive example if they can’t get ahead themselves?
### Appendix E Participant Quote Sources

Table 1: Participant sources for qualitative data (direct quotes)

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