MOBILE HEALTH DEVELOPMENT IN BANGLADESH

THE PERCEIVED BENEFITS OF A MOBILE HEALTH SERVICE IN THE DEVELOPING COUNTRY: BANGLADESH

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A Thesis Submitted to the School of Graduate Studies in Partial Fulfilment of the Requirements for the Degree Master of Science (Global Health)

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TITLE: A qualitative look into the perceived benefits of a mobile health service in the developing country: Bangladesh

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ABSTRACT

Background. The use of mobile technology has become more prevalent within the delivery of healthcare (m-health) within the developing world. Its use is considered convenient and innovative, but little is known about its effectiveness. Although promising, there is a lack of literature pertaining to its overall effectiveness.

Purpose. This study takes the perspectives of threes groups of key stakeholders to describe the m-health service and the perceived benefits of using the mobile health technology implemented by BRAC in the urban slums of Korail, within the capital city: Dhaka, Bangladesh.

Methods. The study uses an exploratory descriptive case study design. The methodology includes demographic questionnaires, and semi-structured interviews. The sample included three groups: the BRAC developers, the community health workers (CHWs) and the villagers.

Conclusion. This study described the perspectives of those involved with the service, defining the m-health service as well as highlighting four major themes: strengths and benefits, knowledge and awareness, challenges and barriers and areas of improvement. The emerging themes found in the study provide paradigms of what to expect when implementing pilot m-health innovation and suggests direction for growth and sustainability.

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ABBREVIATIONS

ANC	Ante-natal care
BRTC	Bangladesh Telecommunication Regulatory Commission
CDI	Composite deprivation index
CHW	Community Health Worker
CIDA	Canadian International Development Agency
EHC	Essential Health Care
HNPP	Health Nutrition and Population Programme
ICT	Information Communication Technology
IMNCS	Improving Maternal, Neonatal and Child Survival Programme
mHIMSS	Mobile Healthcare Information and Management Systems Society
MDG	Millennium Development Goal
MNCH	Maternal, Neonatal and Child Healthcare
MMR	Maternal Mortality Rate
NCD	Non-Communicable Disease
NGO	Non-Governmental Organization
PNC	Post-natal care
PHC	Primary health care
PHW	Peer health worker
PO	Program Organizer
RCT	Randomized Control Trial
SK	Shastho Kormis (Community health workers)
SS	Shastoshebikas (Volunteer health workers)

SMS	Short Message Service
WHO	World Health Organization
WLSA	Wireless-Life Science Alliance

Part I: Introduction

Introduction

According to the Declaration of Alma-Ata for Primary Health Care (PHC) (1978), using "Appropriate health technology" is "an important factor for the success of primary health care (PHC)." Using appropriate technology that is effective and locally accepted has the potential to contribute to global health problems. The People's Republic of Bangladesh has one of the largest populations in the world, at 154.7 million people (World Bank, 2012). With a growing population, and a variety of health problems, mobile health technologies have been proposed and implemented by various organizations to support healthcare development. One of these organizations includes BRAC.

Established in 1972, BRAC, a stand-alone name, which formerly stood for Bangladesh Rural Advancement, is now the developing world's largest Non governmental organization (NGO) (Chowdhury & Bhuiya, 2004). BRAC collectively builds numerous strategies, programmes and innovations to improve the quality of life for vulnerable populations (Chowdhury & Bhuiya, 2004). By identifying the gaps and offering potential solutions, BRAC has managed to tackle poverty through multiple programmes. Within their Health, Nutrition and Population programme, they have implemented various interventions to address maternal, neonatal, and child healthcare (MNCH). With the Millennium Development Goals (MDG) approaching, the Manoshi intervention was designed and implemented under MNCH to address MDG goals 4 and 5: reducing child mortality, and maternal mortality, respectively (Singha, 2012). The objective of the intervention was to provide pregnant women and their family's easy

access to safe delivery centers and health services within the urban slum populations of Dhaka city (Banu, Nahar & Nasreen, 2010).

With its coverage expanded to eight city corporations, the Manoshi program piloted an m-health service in selected urban slums to speed up service delivery (BRAC, 2014). Using this m-health technology, community health workers (CHWs) would collect records and preserve household information to create a virtual database regarding MNCH (BRAC, 2014). This study takes an in-depth look into this m-health initiative, to gain an understanding of its functions within the healthcare structure as well as its overall impact to those using the service.

Study Purpose

The study examines perceptions of an m-health application implemented in the urban slums of Dhaka, Bangladesh. The purpose of this study is to use participants' perspectives to define BRAC's newly implemented m-health technology and to understand how this service is beneficial for those who use it. With a shortage of literature on m-health initiatives within the developing nations, this study takes a qualitative approach in understanding the perceived benefits of this technology. Specifically looking at Bangladesh, the literature surrounding m-health is minimal, providing no substantial conclusions on its impact within their healthcare system. To understand the m-health phenomenon, this study will take an in-depth look into an m-health pilot initiative developed by BRAC to improve the channel of communication between health care services. Through the use of m-health technology, the CHW based within the villages give the local villagers mobile access to health information regarding MNCH information. Because of the infancy of this m-health technology, there is need for background research to provide a introductory understanding.

One research study has been published focusing on this BRAC m-health initiative, focusing on CHWs (Alam *et al.*, 2010). This study expands on Alam, *et al.'s* study by using additional sources of data to include: the BRAC developers, the CHWs and the villagers. This is to ultimately provide a more holistic insight into the m-health initiative. By understanding the opinions of the three sources most commonly involved, the study can highlight perceived areas of success and areas of potential improvements. Using an exploratory case study design, this study uses semi-structured interviews to gain the perspectives of the participants on BRAC's m-health initiative. This can provide a comprehensive understanding of the m-health service, as well as highlights the potential positive influence it has within the urban slum communities within Bangladesh.

Research Question

The objective of this study is to understand the perceived benefits of BRAC's m-health service in the urban slums of the capital city, Dhaka, Bangladesh through the perspectives of its primary users. This study aims to answer the following question:

Through exploratory qualitative analysis, what are the perceptions of those involved with BRAC's m-health pilot initiative implemented within the urban slum populations in Dhaka, Bangladesh?

Study Objectives

Along with the core research question, the following research objectives will be addressed with the different sources: the BRAC developers, the CHWs and the villagers to obtain a comprehensive understanding of the m-health service within the urban slum populations of Dhaka.

The objectives of this exploratory study are to:

1. Describe the different functions and uses of the m-health service, its accessibility within the community, and the frequency in which it used by the recipients.
2. Describe how the m-health service is integrated within the healthcare structure.
3. Describe the training and guidelines of the m-health service, specifically looking at the content and relevancy of the information provided.
4. Describe the monitoring and evaluation methods used for this service, and the frequency at which evaluation occurs.
5. Understand the demographic characteristics of the CHWs, the villagers and the BRAC developers who are involved with the service.
6. Describe how participants perceive the ease of use of the service.
7. Explore and describe the perceived benefits and values of individuals involved in the m-health service, including the opinions of CHWs, BRAC developers and a sample of the recipient villagers.
8. Understand, from the participant's perspectives, the challenges faced with the m-health pilot and the potential future recommendations for this service.

Part II: Background

Introduction to Mobile Health (m-health)

Evolution of Telemedicine

In 1876, Alexander Graham Bell revolutionized the world with his invention of the telephone, connecting people at a distance. Since the 1970s, the introduction of the Internet, and the mobile phone, has not only connected people but has also created the ability to share information and ideas among people. These concepts are integral to the application of telemedicine. According to the World Health Organization (WHO) (2010) the definition of telemedicine is:

> "The delivery of health care services, where distance is a critical factor, by all health care professionals using information and communication technologies for the exchange of valid information for diagnosis, treatment and prevention of disease and injuries, research and evaluation, and for the continuing education of health care providers, all in the interests of advancing the health of individuals and their communities."

Often referred to as 'telehealth' or 'telecare', telemedicine uses information communication technology (ICT) to enable people to have remote access to healthcare. With the recent increased focus on the "dual burden" of diseases in developing countries, whereby both communicable diseases and the emergence of chronic/non-communicable diseases prevail, services under telemedicine can provide a promising support system in mitigating these health concerns (Kahn *et al.*, 2010). As Kahn *et al.* mentions these technologies not only support different levels of healthcare by remote access, but they also enhance the "virtuous cycle," in which the reciprocal relationship between economic development and health improvement is strengthened. The

introduction of telemedicine within healthcare structures has the potential to positively impact this cycle by increasing health levels, which can ultimately provide a healthier workforce for economic growth.

Although the benefits of telemedicine are theoretically substantial, there is the possibility of resistance in its implementation. In the literature review carried out by Tomasi *et al.*, (2004), they found that security, incompatibility among system platforms, and lack of standardization were important barriers faced when introducing health information technology into primary healthcare within developing countries. In addition, the literature consistently found that adoption amongst healthcare professionals was low. It is perceived that this low adoption could be due to their roles being undermined by the influence of the technology, which consequently threatens their autonomy as healthcare providers. This threatened autonomy therefore delays experiencing the intended telemedicine benefits, and also increases the need for continuous input, training and motivation to successfully implement the service (Tomasi *et al.*, 2004). Furthermore, the continuous input adds to the overall costs of telemedicine care, making it an expensive and unnecessary technology that removes the focus from addressing more prominent local issues, such as health behaviours and effective treatments (Rigby, 2002).

Many developing countries use telemedicine, especially where rural and remote localities have minimal access to healthcare services. India is an example, where the growth of telemedicine was largely in response to the large populations in rural areas that had limited access to healthcare (Pal *et al.,* 2005). With 80% of all health centers located within urban areas, catering to only 30% of the population, there was a widespread awareness of the potential advantages of using telemedicine in rural areas (Pal *et al.*, 2005). Similar India, China faces similar rural-urban population discrepancies. According to Xue & Liang (2007) telemedicine was first introduced in China within an academic setting where teleconferencing was used between medical institutions

to demonstrate the potential benefits of telemedicine. This teleconferencing session ultimately caught the attention of the Chinese government, which led to the incorporation of telemedicine as a national policy, forming partnerships among rural hospitals, mobile health stations and established hospitals, in hopes of improving healthcare access to more of the rural population (Xue & Liang, 2007).

The capabilities of telemedicine go beyond the scope of this paper, but it is worth mentioning the penetration of telemedicine within different aspects of healthcare. The telemedicine systems that exists includes real time video teleconferencing (which involves remote live interaction), and store and foreword systems (which involves the transmission of data over the Internet) (Kuo, 2001). The remote interaction and flexibility has allowed telemedicine to be applied in a variety of disciplines, one of which includes tele-pathology. Hitchcock (2011) mentions that through the use of virtual-slide technology, pathologists from around the globe can analyze digital/virtual images of histological samples in remote locations to assist in diagnostic consultation. Similarly a study conducted by Wamala, *et al.*, (2011) found that through the assistance of tele-microscopy and the Internet, pathologists in Germany were able to make the same diagnoses of specimens in Uganda as those making on-site diagnoses using conventional microscopy. Similarly a comparative study between tele-dermatology and face-to-face consultations in Pakistan proved that 81% of the cases had resulted in the same diagnoses (Rashid *et al.*, 2003). Advancing fields within telemedicine also include tele-cardiology and tele-neurology that provide opportunities for remote patients to have access to expert physician advice (Sekar & Vilvanathan, 2007; Patterson *et al.*, 2001).

E-health Versus M-health

Under the umbrella of telemedicine there are often references to both electronic health (e-health) and mobile health (m-health); these are references to the systems through which telemedicine can be delivered. Eysenbach (2001) clearly defined e-health as a broad term that not only encompasses the Internet and ICT, but as a "state-of-mind" that incorporates development of healthcare. M-health is a subset within e-health that utilizes mobile technology, including personal digital assistants and/or wireless devices (WHO, 2011). With the assistance of m-health, CHWs, nurses, physicians, and others can use these technologies to better assist them in remote community healthcare. Looking at Figure 1, it can be seen that mobile phones have significant reach within developing countries, in comparison to other technology and healthcare structures, demonstrating the overall potential m-health has within healthcare systems (Vital Wave Consulting, 2009).

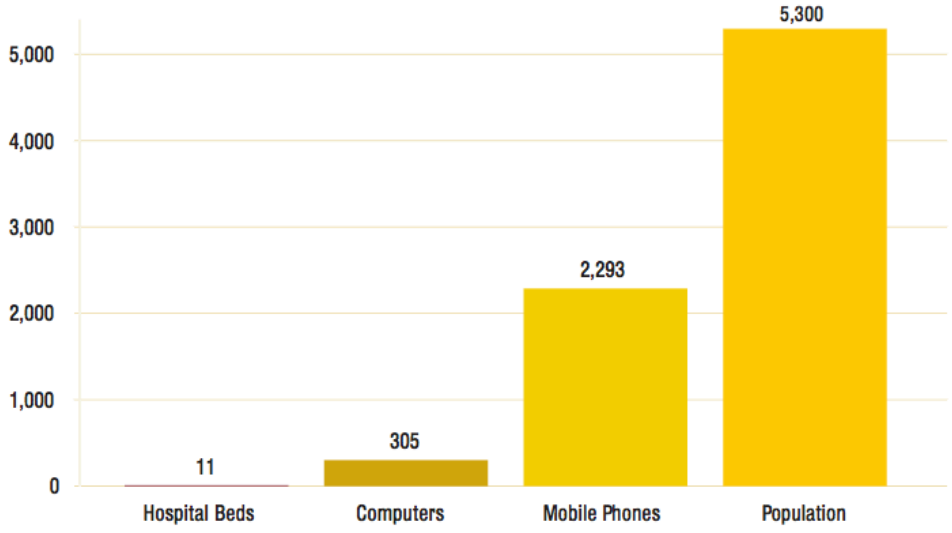

Figure 1: Access to technology and health infrastructures for developing countries (millions).

Retrieved from The Opportunity of Mobile Technology for Healthcare in the Developing World (12), by Vital Wave Consulting, 2009, Washington, D.C. and Berkshire, UK: UN Foundation-Vodafone Foundation Partnership

M-health Technologies

With the accelerated pace in which mobile technology is advancing, there has been increased efforts to integrate this technology into healthcare structures. The growth in mobile communication has led to numerous pilot m-health initiatives, to understand its overall influence within healthcare. According to a report conducted by Vital Wave Consulting in 2009, there were over 50 m-health projects occurring within the developing countries that covered education and awareness, remote data collection, remote monitoring, communication and training for workers, disease and epidemic outbreak tracking and diagnostic and treatment support. All of these were facilitated through various m-health applications including short message service (SMS); mobile help lines; built-in survey software for data collection; built-in diagnostic tools; digital images and videos; and integrated mobile and web-based technologies for the transmission of data. Along with the compendium of the m-health projects mentioned in the aforementioned report, numerous organizations exist that focus on the development of m-health initiatives around the world, these include M-health Alliance, hosted by United Nations; mHIMSS (mobile healthcare information and management systems society); Wireless-Life Science Alliance (WLSA); and American Telemedicine Association.

As previously stated, this paper will address m-health applications and their potential to strengthen healthcare in the developing world, by focusing in on a specific m-health program initiated by BRAC in the developing country of Bangladesh.

Geographical Setting: Bangladesh

Bangladesh's Health Structure

To understand the foundations of telemedicine, specifically m-health, this paper focuses on its application within Bangladesh. Bangladesh has one of the largest populations in the world,

consisting of 154.7 million people (World Bank, 2012). According to Bangladesh's Pocket Book of Statistics, in 2010 it had a population of 146.6 million people, with 109.2 million (74%) in rural settings and 37.4 million (26%) in urban areas (Byuro, 2011). With a population density of 1203 people per square km of land area, and an annual growth rate of 1.39 million people (Byuro, 2011), 1.2% annual change (World Bank, 2014), the population size and growth present difficult challenges for Bangladesh's healthcare sector. In 2009, 25% of the overall population lived in urban slums and now there is an expected increase to approximately 60% by 2030 (Bhuiya *et al.*, 2009) this rapid growth will therefore force healthcare systems in urban developments to find appropriate means to manage and provide quality healthcare service to these migrating masses.

Bangladesh is composed geographically of seven divisions (regions); Barisal, Chittagong, Dhaka, Khulna, Rajshahi, Rangpur and Sylhet (Figure 2), 64 districts and 481 upazilas (UNICEF, 2010).

Figure 2: Division of Bangladesh.

Retrieved from Maps of the World, 2013. Retrieved April 20, 2014 from http://www.mapsofworld.com/bangladesh/bangladesh-political-map.html

To understand the healthcare structure that exists within Bangladesh, Figure 3 provides a simplified system map of the managerial hierarchy of healthcare structure under the Directorate General of Health Service which is the largest executing authority under the Ministry of Health and Family Welfare (Directorate General of Health Service, 2014). In addition, this system map provides a breakdown of the different types of facilities available at each of the administrative levels between national to ward.

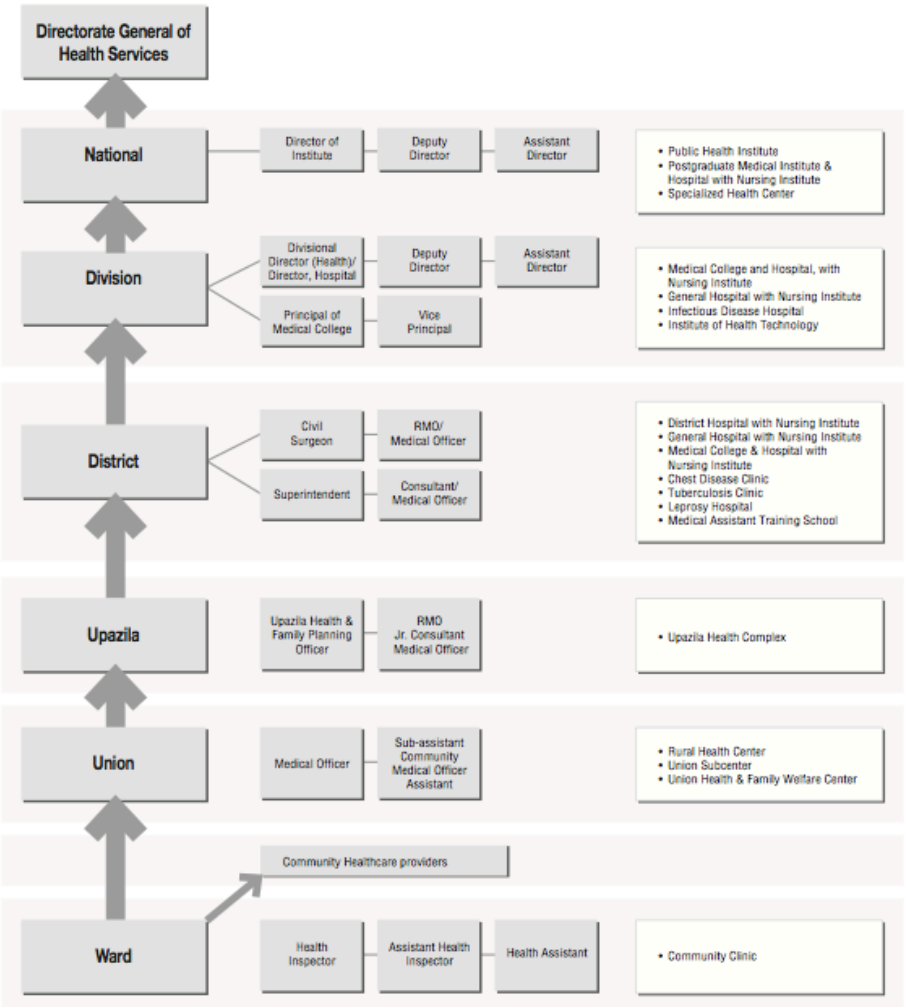

Figure 3: Managerial hierarchies from national to the ward level

Retrieved from Health Bulletin 2013 (22), by Directorate General of Health Service, 2014, Dhaka: Bangladesh, Ministry of Health & Family Welfare, Government. of the People's Republic of Bangladesh

Although there is regulated structure, each of the divisions within Bangladesh is not homogenous in terms of their economies, educational system, healthcare system and other attributes. According to the national case report conducted by UNICEF (2010) the Syhlet, Dhaka and Chittagong divisions (located in the North-east, North-central and South-east respectively) have the highest composite deprivation index (CDI); a measure that indicates the most deprived areas. Indicators that are components of the CDI include the number skilled birth attendants

(which correlates with under-age-five mortality rates); the net attendance ratios in secondary schools (correlates with poverty levels); the percentage using improved sanitation; and the adult literacy for women (also correlates to poverty levels). In accordance to the CDI values, it is apparent that some divisions are more deprived than others from appropriate access to basic necessities, these including health, education and sanitation services. Within healthcare professionals, the national deprivation is further highlighted with the alarmingly high numbers of 2860 patients per physician and 5720 patients per nurse (Byuro 2011). The lack of healthcare providers and services further highlights the need to develop healthcare throughout the country.

Bangladesh's Mobile Technology

The high growth rate in access to telecommunications and ICT in Bangladesh, has the potential to address concerns related to the lack of healthcare services throughout the country. Six mobile providers function within the country, which include Grameen Phone, Banglalink, Robi, Airtel, Citycell and Teletalk. With each of the providers informing the Bangladesh Telecommunication Regulatory Commission (BRTC) on their total number of active subscribers on a monthly basis, BTRC can measure the overall number of active users per month. In April 2012, there were approximately 90,636 million active mobile subscribers and by April 2014 this number had grown to 115,627 million active mobile subscribers (BTRC, 2014), a calculated 13.8% annual growth rate. In addition to these statistics, the *Daily Star* national newspaper noted that the International Food Policy Research Institute had conducted a national survey and had found that 73% of the rural population had access to mobile phones ("73pc rural households", 2013). These growing numbers of active users highlights the possibilities of using mobile technology to assist and support healthcare systems within Bangladesh. These numbers are the

recent motivations for many organizations including BRAC, whereby introducing and developing m-health innovations.

BRAC

Organization Overview

BRAC was initially set up in 1972 in response to Bangladesh's recent independence from Pakistan. BRAC started initially as Bangladesh Rehabilitation Assistance Committee to focus on short-term issues. With a shift in objectives to long-term development, BRAC was renamed to Bangladesh Rural Advancement Committee; finally by 1996 it became BRAC (Chowdhury & Bhuiya, 2004). BRAC has an integral role in alleviating poverty throughout the country. According to the International Non-Governmental Organization (INGO) Accountability Report 2012, BRAC continues to be one of the largest NGOs in the world, with over 100,000 employers and BRAC workforce of over 135 million people in 11 countries, (Kairy, 2012). Bangladesh had a BRAC workforce of over 106,570 people (part time, full time, and volunteers (Kairy, 2012).

Within this report, in year 2012, BRAC's total income was US$ 521,401,892 with 29% from donor grants (top five donors include: the Department for International Development (DFID); AusAID; Embassy of the Kingdom of the Netherlands; The Global Fund; and the Department of Foreign Affairs, Trade, and Development formerly known as Canadian International Development Agency (CIDA)), 19% from revenue of income generating projects, 10% from revenue of program support enterprises, 36% from service charges on microfinance loans, 3% from interest on bank accounts and fixed deposits, 0.003% from investment income, 0.01% from other income and 0.002% from house property income (Kairy, 2012). BRAC's organizational structure can be viewed in Figure 4, displaying the internal administrative structure

of the organization, with 29 members within the general body, and 10 elected members within the governing body (BRAC, 2013).

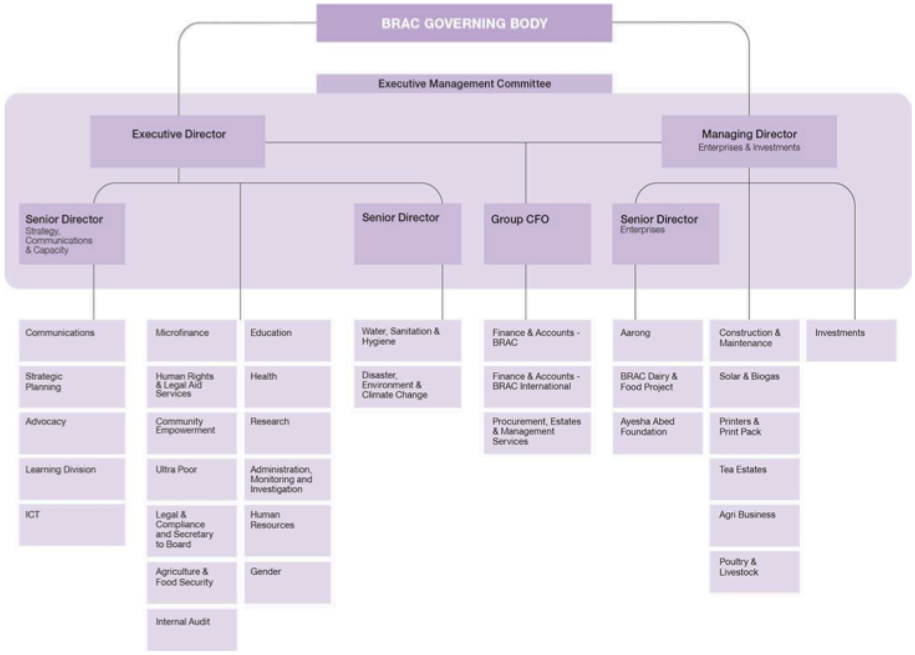

Figure 4: BRAC Organizational Structure

Retrieved from BRAC Annual Report 2012 (46), by BRAC, 2014, Dhaka: Bangladesh, BRAC

To achieve BRAC's priority objectives, which are alleviating poverty and empowering the poor, specifically empowerment of women, BRAC programs focus on economic and social development issues (Ahmed & French, 2006). The microfinance programs provide loans, savings and credit services, and microenterprise development in poultry, livestock, aquaculture, agriculture, and agroforestry. Social programs focus on education, health (which incorporates nutrition, sanitation, family planning, immunization, etc.) and legal awareness (which incorporates social and human rights awareness) (Ahmed & French, 2006).

With the work conducted by BRAC encompassing a broad range of services, it encourages the establishment of relationships and collaborations with multiple stakeholders.

According to Ahmed, *et al.*, (2013), this polycentric dynamic that exists among the government, private sector, NGOs and informal sector, harnesses pluralism that can help improve health in Bangladesh. Encouraging this dynamic can contribute further towards the heterogeneity of the health sector, the growing demands of diversity, and lastly the advancements in innovation. Within the Bangladesh, BRAC is recognized as one of these primary stakeholders that contributes the country's overall development. Although this pluralistic approach is beneficial, as mentioned by Ahmed, *et al.*, Bangladesh still suffers from overdependence on the government, inflexible contractual agreements, lack of accountability and lack of accuracy. Undeniably, however, it is through the existence of NGOs, such as BRAC, that health service delivery has improved within Bangladesh (Arifeen, *et al.*, 2013). As mentioned by Arifeen, *et al.*, (2013) BRAC's community based approaches and partnerships have contributed to the existing small health workforce in Bangladesh. With 0.58 health workers per 1000 people, Bangladesh is below the WHO's requirements of 2.28 health workers per 1000 population (Arifeen, *et al.*, 2013). With the introduction of community-based approaches, between 2011 and 2012, BRAC was able to employ and educate 105,631 CHWs out of the 219,000 CHWs nationwide, making them the largest provider of CHWs in the country. Furthermore BRAC's volunteer CHWs (also referred to as Shastho Shebikas) have also increased in number, providing larger geographic coverage and rapid mobilization. This large population of BRAC employees identifies the influence they have within Bangladesh's health development. By providing CHWs, BRAC is not only creating a health workforce, but are also identifying CHWs as community change agents (Arifeen, *et al.*, 2013).

Health, Nutrition and Population Programme (HNPP)

The development of community-based initiatives has the ability to address the multiple facets of health, and these fall under the Health, Nutrition and Population Programme (HNPP) at BRAC. This programme was developed to combat the numerous health concerns within the Bangladesh. According to their website, the HNPP has developed the following initiatives: Essential Health Care (EHC), the foundation of BRAC's health programme, providing preventative and basic curative service; Maternal Neonatal and Child Health (MNCH) Programme, which is divided into Manoshi and Improving Maternal, Neonatal and Child Survival Programme (IMNCS) catering to urban and rural populations respectively; Tuberculosis Control Programme; Malaria Control Programme; Alive and Thrive, which aims to reduce under-nutrition and death from malnutrition; Bangladesh Sprinkles programme, which prevents and control iron deficiency anemia and other micronutrient deficiencies; eye care interventions, to eliminate blindness; and lastly Non-Communicable Disease Programme, to reduce the burden of chronic non communicable disease and promote healthier living (BRAC, 2014). With the numerous interventions implemented throughout Bangladesh, the essential part of the HNPP is the bridging of communities with the formal health systems, all of which is carried out by BRACs frontline CHWs (BRAC Annual Report, 2012). The developments made by HNPP have in large improved access to vulnerable populations, as well as provided the population with quality health service. To demonstrate the overall influence of these development programmes within the community, a study conducted by Chowdhury & Bhuiya (2002), found that rural mothers who participated in BRAC development programmes had a substantial reduction in child mortality in comparison to those mothers who hd not participated. The programmes therefore highlight the immense impact and potential these programmes have within the nation.

Maternal Neonatal and Child Health (MNCH) Programme

The developments within HNPP are definitely substantial; however some of the major driving components are within the MNCH initiatives. According to the MDG Bangladesh Report 2012, Bangladesh has reduced its maternal mortality rate (per 100,000 births) from 574 in 1990, to 194 in 2010; reduced their under-five mortality rate (per 1,000 live births) from 146 in 1990 to 53 in 2011; and infant mortality rate (per 1,000 live births) from 92 in 1990 to 43 in 2011. Although these statistics are promising, there are still challenges in achieving the expected MDG goals by 2015 (143 for maternal mortality rate, 48 (per 1,000 live births) for under-five mortality rate and 31 (per 1,000 live births) for infant mortality rate). BRAC's development programmes are significant contributors to these declines, and this organization continues to innovate in order to achieve these expected goals.

As mentioned previously, the MNCH programmes are divided into rural and urban programs: IMNCS and Manoshi respectively. The IMNCS, successfully piloted in 2005 in the Nilphamary district, expanded to 10 rural districts, catering to 21 million recipients (Singha, 2012). With the aid of CHWs, including birth attendants as well as village health committees, this project focused on behavior change in the community, by encouraging rural villagers to visit their health facilities and work with their staff to address pregnancy, newborn, and child healthcare (Singha, 2012).

With similar concepts in mind, the five-year Manoshi projected was implemented in 2007 providing essential MNCH services to urban slum populations. These services eventually expanded throughout all the slums in Dhaka city by 2009 and to other city corporations by 2011. The program builds from a chain of staff members, starting with the CHWS: the Shasthoshebikas/volunteers (SS) and the Shasthya Karmis (SK); the Programme organizer (PO); the Branch Manager; and finally the Regional Manager. The SSs, who are volunteers, work

through incentives, identifying pregnant women and referring high-risk patients within a 200 household radius. The SKs, who are have basic medical training, are the ground level workers that look after approximately 8-10 SSs, covering around 2,000 households within their community. Their purpose is to frequently visit all the women who are pregnant, and recent mothers within their community ensuring that they receive healthcare guidance. The PO has multiple duties, including monitoring SKs, and overall surveillance of the community health. Lastly the Branch and Regional Manager oversee and manage all the levels below. The population breakdown and employee numbers are further detailed in Table 1.

Table 1: Kunipara Population and Employee details

BRAC HNPP (Manoshi) Mogbazar (Kuniparpa), Dhaka	
Particulars	Number
Total Number of Slums	7
Total Households	16589
Total Population	49759
Men	24856
Women	24903
Delivery Centers	3
Total Program Organizers	3
Maternal Mid Wives	5
Shasto Kormis	5
Shastoshebikas	43
Urban Birth Attendant	7

To understand the impact of the Manoshi project, Alam et al, (2010) conducted a comparative study between Manoshi project sites and non-project slums. The Manoshi project sites offered the following services: capacity building for CHWs and birth attendants; health services for pregnant women, neonates and under-five children; referrals to quality health facilities as well as connections to government and NGO staff and lastly community empowerment through the development of women's groups. When comparing the Manoshi project sites and non-project slums, the Manoshi site outperformed the slums whereby demonstrating faster and higher rates of positive change within the community compared to the non-project slum.

With these accomplishments, the Manoshi project continues to develop its objectives to ensure that their service and staff are improving the quality of care. In conjunction with the growth in mobile communications, Manoshi decided to pilot an m-health initiative in selected urban slums of Dhaka that could better support the roles of CHWs. In partnership with Click Diagnostics, software was created to assist CHWs in data collection, which could increase efficiency as well as provide real time data on the CHWs daily progress. Although Alam *et al.*, (2010) conducted a study understanding the intervention's impact on CHWs, still limited literature is available regarding its impact within the whole community. With the lack of published information available, the purpose of this study will be to address the perspectives of all the sources involved with this initiative, including the villagers who are the recipients of the service, the CHWs who provide the service and the BRAC employees who developed the service. These perspectives will provide an understanding of the perceived benefits of BRAC's newly implemented m-health service.

Part III: Literature review

Methodology

This review explores current m-health technologies that exist within developing countries. Because minimal data are available within Bangladesh on the evaluation and progress of the m-health services described above, this review initially begins with an overall analysis of m-health applications used in developing countries. This is followed by its potential benefits within healthcare, the potential barriers that tend to be encountered with these applications and lastly focusing on any on going m-health technology research that specifically pertains to the Bangladeshi context.

The keywords that were used for this literature review include developing countries, telemedicine, mobile health, mobile health technology, portable health technology, Bangladesh, BRAC, and Manoshi. The electronic databases that were searched include Pubmed/Medline and Google Scholar. The inclusion criteria included articles, reports and conference proceedings published from the year 2000 and onwards; the existence of an abstract; a developing country setting and research pertaining specifically to m-health technology. The exclusion criteria dismissed articles that were not written in English; were published prior to the year 2000 or were focused on the technical components of the device. Twenty-seven articles were found that met the inclusion criteria. Within these, seventeen were individual m-health studies, four were systematic reviews and six pertained to m-health studies in Bangladesh (Figure 5).

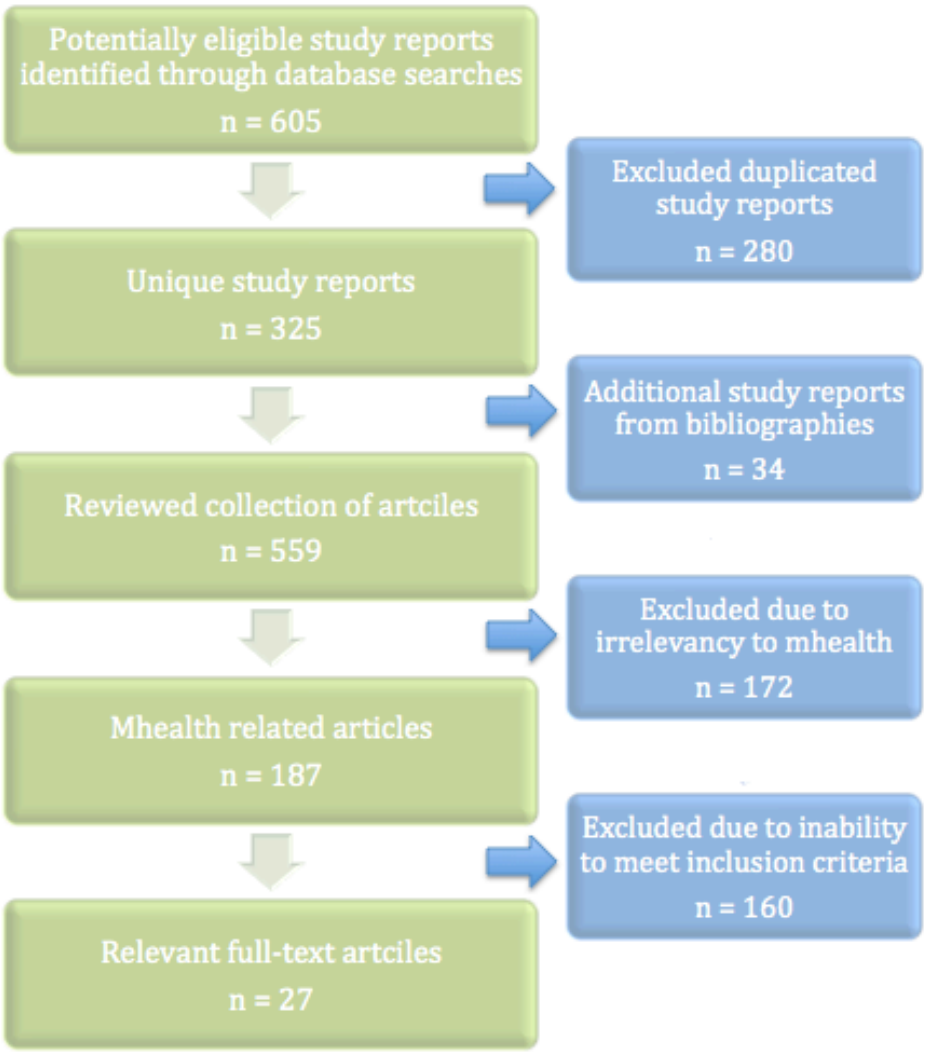

Figure 5: Literature Review Search

M-health applications

The potential to use m-health in developing countries encompasses many different innovative ideas. According to the WHO's Global Observatory on E-health (2012) global m-health falls into these categories: Communication between individuals and health services, communication between health services and individuals, consultation among healthcare professionals, intersectoral communication in emergencies, health monitoring and surveillance,

and lastly access to information for healthcare professionals at point of care. In relation to the literature found, most of the aforementioned categories occurred together in one paper. This review addresses the m-health technologies in collaboration with CHWs, in relation to disease control and lastly in the promotion of health awareness.

M-health in collaboration with Community Health Workers

A primary problem in all developing countries is the lack of skilled health workers available throughout the country. To address this gap immense attention has been put on CHWs and their impact on communities (Lehmann & Sanders, 2007). In a systematic review Braun *et al.* (2013) suggests that CHW engagement allows increased reach to individuals who have limited access to healthcare services, improvements in healthcare systems, and lowering of costs due to the decentralization of healthcare services, and furthermore the addition of m-health technology can enhance CHWs' overall performance.

Braun *et al.*, (2013) reviewed 28 studies where m-health technology was most commonly used for data collection, decision support, alerts and reminders, information on demand, facilitating CHW activities and direct provision of care. Braun *et al.*, identified four different areas in which m-health could better serve CHWs in improving the delivery of health services: process improvement and technology development; standards and guidelines; education and training and leadership and management. While most of the studies reviewed were in the "process and improvement" category, the review highlighted that m-health enabled CHWs to collect high quality and timely data, and that the data collected, in comparison to paper-based data, were resistant to error and loss. Furthermore, these m-health tools allowed for real-time review and rapid response by caregivers. An example of data collection quality is presented in a cross-sectional study conducted in Peru, where sexual behaviour data were collected either using a

handheld computer or a paper-based questionnaire (Bernabe-Ortiz *et al.*, 2008). In the first survey participants were asked to fill out a paper-based questionnaire, followed by a handheld computer questionnaire. In the second survey, the same participants were divided into the paper-based questionnaire or the handheld computer questionnaire. With the first survey showing almost perfect agreement between the data collected using the handheld computer and the paper-based questionnaire, the second survey was able to identify that the handheld computer questionnaires had statistically higher accuracy and faster collection times in comparison to the paper-based questionnaires. Even with the limitations of this study, which included recall bias during the collection methods, as well as the small sample size reducing the generalizability of the results, the most important finding was that the data obtained was more credible and precise when collected through an electronic platform.

Another essential use of m-health technology was the ability for CHWs to adhere to "standards and guidelines" primarily due to the fact that the CHWs had instant support from their superiors when needed and constant reminders to keep them on track (Braun, *et al.*, 2013). Jones *et al.* (2012) verified the adherence to standards and guidelines in a qualitative study where the perceptions and experiences of CHWs were collected after a randomized controlled trail (RCT) on receiving text messages about malaria outpatient management. Conducting in-depth interviews with 24 CHWs, the results captured how they perceived the text message service, appreciating the frequency, timing and length of the messages as well as the duration of the intervention; and how these messages were mechanisms of actions, reminding the CHWs' of their responsibilities and creating continued habit and behavior even after the text message intervention had stopped. An essential element with this study was that the CHWs didn't feel that they were only receiving text message reminders, but that they were part of a team that was supporting their clinical practice (Jones *et al.*, 2012).

Education and training are essential components for CHWs; an RCT conducted by Arango, *et al.*, (2011) in Colombia, showed that m-health technology was an effective method of training in comparison to the control; traditional paper based guidelines. In this crossover study design study the CHWs were divided into two groups: Group A was exposed to the intervention (m-health) followed by the control, and Group B was exposed to the control then the intervention (paper). Although a limitation of the study pertained to its laboratory setting, the results were able to capture how error rates were more prominent for Group B when they were placed in control settings. However once participants were placed in the m-health group the error rates decreased. Similarly when analysing compliance rates, initially the paper group had low compliance in the control setting, but increased their compliance when placed in the m-health setting. In contrast, Group A, when placed in the intervention setting, had low error rates and high compliance. However once placed in the control setting, the error rates increased and compliance decreased. This highlights the fact that the rich media format on mobile phones has the ability to ensure accuracy and compliance as opposed to the paper-based guidelines. Therefore in accordance with this review, education and training through m-health technologies can reduce errors, not only due to consistent advice from superiors, but also through frequent and ready accessibility to information, all of which were available in a timely manner (Braun, *et al.*, 2013).

Lastly, in reference to leadership and management, CHWs can take their own initiatives and be independent within their roles providing appropriate care through the reinforcement of reminders, ease of accessibility and assistance from their superiors through the use of m-health technology (Braun, *et al.*, 2013). The CHWs' leadership and management is exemplified in the behaviour change in Jones' et al, (2012) study, but also in a study conducted by DeRenzi *et al.*, (2012) in Tanzania. Initially a pilot study was conducted to evaluate the impact of short message service (SMS) reminders in improving CHW patient visits. Although the initial pilot study had a

very small sample size, the study was able to show that there was an increase in performance and promptness when SMS interventions were used. In DeRenzi's *et al.* (2012) consecutive studies, the first study evaluated a reminder system that notified CHWs, which then escalated to notifying the CHW's supervisor after being several days overdue for patient visits. With the assistance of an SMS reminder system, CHWs were able to reduce the average number of days they were overdue in comparison to the CHWs' in the control group. In the second study, when the notification to the supervisor was removed, the average number of days increased, decreasing CHW performance. This demonstrates that, with the assistance of m-health technology, there is not only better management of CHW tasks, but with continued supervision from a distance m-health can improve their clinical performance.

Braun *et al.*, mention the ways m-health can strengthen the healthcare system. It also highlights potential benefits in healthcare practice, which include quality of care, efficiency of services, CHW learning, and system outcome. The review by Braun *et al.*, found that m-health assistance allowed fewer errors, better compliance to healthcare standards, and enhanced educational and training methods (through SMS, calls, videos and audio), which contributed to an increase in quality of care. Efficiency was exemplified through the overall savings in costs. With reduced working hours for CHWs, and reduced fuel and operational costs, it ultimately increased the ability for CHWs to assist more patients. In addition, the learning and utilization of m-health services allowed CHWs to experience higher levels of confidence in their practice, which was further strengthened their ability to gain timely knowledge while catering to their patients' needs (Braun *et al.,* 2013).

Although the Braun *et al.,* review effectively reviewed the dynamic between CHWs and m-health technology, it also addressed the limitations they encountered. They suggested potential for publication bias, as results, especially with negative findings, could be under-reported.

Furthermore, due to the novelty of this technology, a paucity of research is available at this point that can provide concrete conclusions on m-health technology.

M-health in disease control

A systematic review conducted by Deglise, *et al.,* (2012a) on SMS for disease control focused on sites where these services were offered, the diseases and purposes they catered to, the types of communication used, and the outcomes observed when these services were used. Using 98 SMS-based interventions, it was found that the main localities focused on developing countries which included Africa where South African and Kenyan research dominated, and Asia where Indian and Chinese research dominated. Most interventions focused on HIV/AIDS, with a few studies of sexual health, tuberculosis, malaria and avian influenza. The main sources of communication involved mass text messages or customized services after receiver registration that allowed active participation by the users.

Deglise, *et al.,* categorized outcomes of m-health services into four groups: prevention, surveillance, management and compliance. In disease prevention, although limited information was available on the behaviour changes experienced when people were exposed to SMS preventative messaging, there was overall positive feedback from the population. In research by Clemmons & Shillingi (2009), the use of a text message helpline service called Text Me! Flash Me! Helpline catered to the most-at-risk-populations including men who have sex with men and female sex workers and provided access to information regarding HIV/AIDS. This not only increased the sexually transmitted infection knowledge of the participant, but also introduced and reminded them to adopt key behaviours as well as to take advantage of referrals to counselling and testing services. Clients were positive to the service, primarily due to the fact that the support was confidential.

When addressing disease surveillance, Deglise, *et al.,* found that m-health technologies reduced delays and prevented errors in comparison to the traditional paper-based systems. This was demonstrated in an RCT carried out by Yu *et al.*, (2009) where they were able to compare the efficacy of data collection with traditional paper-based and mobile personal digital assistant based format. As mentioned in previous studies, the results proved that personal digital assistants created fewer errors, consumed less time, reduced overall costs, and allowed for increased workflow from data preparation, collection and validation, this providing an effective solution for public health surveillance. It is noteworthy to mention that participants and researchers of the study were all students in the Fiji School of Medicine, which reduces the overall generalizability of the study.

In addition, the review by Deglise, *et al* suggests that SMS reporting offered faster and immediate communication, which is of high value during emergency situations. This is exemplified in a study conducted by Yang *et al.* (2009) where mobile phones were used for infectious disease surveillance after the Sichuan Earthquake in China. With the landline based reporting system impaired during the earthquake, a simplified m-health service was implemented to restore the reporting capacity of healthcare agencies. With reporting of infectious disease required by law, this m-health service allowed healthcare agencies to update their national database. This highlights the potential as well as the necessity for m-health technology to be integrated within emergency response plans.

Similarly Deglise, *et al.*, mention positive responses to disease management, since SMS applications helped facilitate communications between healthcare workers and healthcare users. These positive perceptions on m-health technology were expressed in an editorial written by Chang *et al.*, (2008), in response to the human resource crisis of peer health workers, mobile phones and HIV care in Rakai, Uganda. By focusing on a study that involved peer health workers

(who have HIV themselves) submitting health status updates on their appointed HIV/AIDS patients through mobile phones, Chang *et al.*, shows that clinical staff members agreed that the intervention improved the overall health of patients, and patient compliance. The editorial further suggests that these mobile interventions are simple, inexpensive, and empowering tools for PHWs in response to finding adequate human resources to treat HIV/AIDS as well as enhancing communication between peer health workers and higher-level providers.

The final category reviewed by Deglise, *et al.*, is disease compliance, in which attendance to appointments and adherence to treatment increased. SMS support groups were well received by those patients isolated or stigmatized by their disease. However health outcomes marginally improved. Aside from studies mentioned in the review, two similar RCTs conducted in Kenya were able to show how antiretroviral therapy adherence increased with the addition of text message services (Pop-Eleches *et al.,* 2011; Lester *et al.*, 2010). In the study by Pop-Eleches *et al.*, (2011), weekly SMS interventions increased participant achievement to 90% adherence to ART as well as decreased the number of treatment interruptions when compared to the control group who received no reminders. In a study by Lester *et al.*, (2010) similar results were found. These were verified through 12-month viral load inspections, in which plasma HIV-1 RNA was collected from participants to confirm adherence. Those that had the SMS service were more likely to be virologically suppressed (meeting adherence levels) while those who did not have the SMS service were more likely to be virological failures. In another RCT, taking place in Zanzibar which has a national issue of maternal mortality due to unskilled attendance during delivery, Lund *et al.*, (2012) showed that through the use of an SMS service targeted at pregnant women, they were able to increase the percentage of skilled attendance during delivery (60% versus 47% for those without the service). This outcome was of high priority especially when Zanzibar is

trying to achieve its Millennium Development goals (MDG) 4 and 5 that encompass the reduction in child mortality and improvement in maternal health respectively, (United Nations, 2013).

As seen by the foregoing studies, the infancy of m-health technology creates many limitations including publication bias towards positive outcomes. Similarly, with the novelty of the technology and the constant advancements in the field, some innovators may feel the need to protect their research results preventing disclosure on their m-health innovation. Further difficulty comes from the grey literature sources, which have limited reliability. This highlights the need for more high quality research that can bring credibility to m-health's overall impact.

M-Health in promoting awareness

As discussed, m-health has the ability to assist CHWs, as well as to support disease control, but it can also support awareness. Although there is limited literature is available within this category, it does impact populations.

In a nationally implemented study, the cell PREVEN project that was initially piloted in three cities of Peru, was an sexually transmitted disease transmission prevention initiative (Curioso, 2005). Female sex workers, who are important factors in the transmissions of sexually transmitted disease, were linked to a healthcare team network through cell phones. They were asked to leave voice messages or SMS messages to report any adverse events with the PREVEN staff. The FSWs would then receive responses from the healthcare team concerning any potential risks, and notifications were transmitted and actions were taken. This gave FSWs immediate feedback when needed. It also allowed access to FSW medical histories and reduced the number of data entry errors. Through the surveillance of high-risk transmitters of STDs, the project's use of the m-health initiative not only promoted awareness of the potential risks for FSWs, but also had the ability to control, prevent and monitor STD transmission.

In a similar context, the Clemmons & Shillingi (2009) study mentioned previously, was able to show how a text message helpline service for most-at-risk populations provided awareness about HIV/AIDS. This increased client knowledge about HIV/AIDS, advised about healthy behaviours that could prevent transmission of the disease, and introduced them to counselling and testing locations for further information. Positive feedback from clients suggested that this service was helpful in providing confidential access to vital advice and information.

Another example appears in an exploratory article by Curioso & Mechael (2010), on the on-going Project Masiluleke in South Africa, which uses mobile technology as a tool for bringing awareness about HIV and tuberculosis prevention. This successful and expanding initiative uses extra space available in text messages, to automatically insert the contact numbers for HIV/AIDs call centers. By collaborating with local organizations as well as communication providers, this project has been able to effectively bring awareness to a prominent health problem. This project can clearly be replicated in other countries, to address public health concerns worldwide.

Although limited research pertains to m-health in promoting awareness, the few studies mentioned above all contribute to increased awareness of prominent health issues. The ability to learn, manage and monitor through the use of m-health technology allows both the receivers and providers of the service a greater level of awareness and understanding of the health concerns.

Benefits of m-Health

In a publication by the United Nations and Vodafone Foundation Technology Partnership, in 2008, the concrete benefits from m-health development within developing countries include increased access to healthcare and health-related information, particularly for hard to reach populations, improved ability to diagnose and track diseases, timelier, more

actionable public health information and expanded access to on-going medical education and training for health workers (Vital Wave Consulting, 2008).

From most of the studies discussed thus far, the benefits of using m-health are substantial, from the increased benefits to CHWs, the ability to control disease, as well as the ability to increase awareness. Apart from the benefits mentioned, Kahn et al, (2010) describes the potential benefits of using m-health in large geographic areas, in community settings and for individuals. On the larger geographical scale, the benefits encompass health disaster avoidance and mitigation through the transmission of rapid updates and advice, health promotion, increased knowledge on health diagnosis and care, and disease surveillance. In the community setting, individuals can share experiences with healthcare professionals as well as amongst peers. In the individual setting, confidential provider to patient communication can be easily managed with customized responses catering to patient needs. This customized communication strategy increases quality of care and adherence to health self-management strategies as well as improved knowledge about individual health. The benefits of quality care, adherence and improved knowledge not only stand alone, but as further elaborated by Kahn et al, they contribute to a virtuous cycle, in which improved health increases economic development and vice versa. Positive results from m-health initiatives can potentially foster the development of upgraded platforms that can ultimately enhance healthcare systems.

Upgrades to health systems that involve m-health technology are often associated with high initial investments. However as suggested in a pilot study conducted by Mahmud, *et al.*, (2010) in Malawi, the use of m-health technology ultimately can result in large cost reductions. The study involved introducing cell phones to 75 CHWs, which they used over a six-month period. The purpose was to use these cell phones to communicate with hospital staff working at an established hospital to address the on going cases in the field clinics. By observing network

usage statistics, the messages were categorized into nine different groups in descending order of frequency: patient reporting and referrals, requests for additional SMS units, reporting symptoms, requests for help, death notifications, meetings, requesting supplies and lastly phone problems. This allowed the CHWs to maintain frequent contact with the clinics for various concerns without having to be physically present. By observing the net financial savings and the worker time involved, the results showed savings in transportation costs and working time, resulting in an overall savings of $2750. These savings allowed the hospital and clinics to increase their roster by 100 patients. Although this pilot involved a small sample size, it indicates that there is an opportunity for larger scale cost reductions.

In addition to this, the previously mentioned studies by Lester *et al.*, (2010), and Pop-Eleches *et al.*, (2011), show how m-health technology has the ability to positively impact health behaviours. Both demonstrated how their projects were successful in improving anti-retroviral therapy treatment adherence. Thirumurthy & Lester (2012), further highlight these behaviour changes suggesting that anti-retroviral therapy treatment is only one of the many treatments that can be targeted through m-health technology. M-health can be applied to a broad range of health related behaviours including treatment programs for malaria, tuberculosis, non-communicable diseases, maternal healthcare, and preventative care, which are now being piloted through various organizations. The cost-effectiveness of the service, the flexibility of its application, as well as its potential reach, has the ability to increase the overall effectiveness of these treatment adherence programs.

Smartphone technology is primarily established in developed countries where there is wealth, active use and more opportunities within healthcare. However as mentioned above, simple mobile technologies involving text messages or phone calls can be used in developing countries, supporting more effective and modern m-health technology. Normally, developed

countries undergo infrastructure development to support their on-going advancements in technology, but Bastawrous & Armstrong, (2013) suggest that developing countries are capable of "leapfrogging;" a term used to describe skipping the normal progression of landline technology to go straight to the modern means of m-health technology. Leapfrogging will therefore be advantageous for developing countries as their accelerated progression can help mitigate national health concerns, specifically within those countries that lack the human resource capacity to sustain quality health care. Even though many developing countries are leapfrogging to m-health, which have can provide extensive benefits, there are limitations to such an approach, and the lack of a sustainable wireless infrastructure and other barriers can potentially hinder m-health development. Furthermore, the lack of evaluation of many of these studies occurring in these countries prevents finding a solid understanding of the overall benefits that m-health has to offer.

Barriers to m-Health

The majority of the m-health literature, especially as it relates to developing countries, deals with projects that are in their infancy. This makes it difficult to find evidence-based examples and principles to show the efficacy of m-health use, creating a primary barrier for m-health research (WHO, 2011).

Although m-health technology is advancing, Deglise *et al.*, (2012a) mentions in their systematic review a lack of high quality literature, published from accredited sources, which discusses the overall influence m-health has in healthcare development. The systematic review by Braun *et al.* (2013), mentions that most studies that have been conducted are pilot studies, providing only a limited understanding of how m-health could be effective in large scale or nationwide implementations. For m-health to be successfully adopted, countries need to address

the related social and policy challenges, including nationwide standardization as well as government cooperation (Braun *et al.*, 2013).

A systematic review by Gurman, Rubin & Roess (2012), assessed specific studies that pertained to behaviour change communication interventions using m-health technology. What was integral in this review was identifying studies that were methodologically sound, had solid evidence, and most importantly had high quality interventions. Including only 16 published studies, the review discussed how these interventions attempted to address nine quality assessment requirements. They found that *two-way communication*; *technology platform selection* and *understanding the audience* were all well represented in most of the studies, suggesting that m-health has the capability to cater its service to meet the needs of the target audience. Similarly almost half of the studies considered *targeting and tailoring the content* for the audience, *considered their comprehension levels* and *ensured their privacy,* all of which address meeting the needs of the population. On the contrary side, the review found that the *timing of the communication* within studies was not well represented, which could be accounted for by the lack of constructive research in messaging strategies. Similarly most studies lack *long-term evaluation* and *cost-benefit analysis*, which are typical problems across most of the m-health literature. Even with a slightly higher number of studies discussing cost benefits, most of these studies were unable to effectively show how significant m-health costs are. The overall finding of the review by Gurman, Rubin & Roess strengthens the idea that m-health research is still in its infancy. Although there were several limitations in the study, including the small amount of literature used; the comparison of the variety of target populations used in the studies; and the fact that some studies were sponsored by the same organization, the overall message still remains that there is a need for more constructive and long-term research.

In another systematic review conducted by Chib, van Velhoven & Car (2014) addressing m-health adoption in developing countries, they found that although a growing body of published literature is on this topic, data on its effectiveness is lacking. With no template available for the implementation and sustainability of such technology, most reviews have differing criteria for m-health innovations making it harder to assess the scope of success. Within the review by Chib, van Velhoven & Car, using 53 studies within the developing world, Chib, van Velhoven & Car show limited reported improvements of m-health interventions on established health indicators, cost effectiveness and adverse effects, which are necessary for policymakers to recognize its importance and to engage with the technology. To build a solid base of evidence, Chib, van Velhoven & Car suggest that studies need to establish technological, theoretical and measurement standards as well as focus on evaluation, in order to achieve to a more comprehensive understanding of how m-health can contribute to developing nations.

Similarly, Van Velthoven *et al.* (2013) highlight the same problem with m-health technologies as well as its impact on health indicators. Van Velthoven *et al.* recommend tackling these barriers by surveying m-health services in three specific areas: household surveys, monitoring of national/large-scale programs and lastly measuring the global burden of disease. First, the collection of household surveys provides estimates of health, as well as the coverage of health interventions, thus creating the foundation for future initiatives. Secondly, m-health can help facilitate national/large-scale programs through continuous real-time data collection methods, providing essential regional data, which can consequently be evaluated to measure the global burden of disease. These three areas bring credibility and validity to the use of m-health technology, and allows individual countries to benefit from using a more cost-effective and faster methods to gain accurate data on national statistics, which can be uses to guide future

interventions. This win-win situation could therefore be initial steps towards improving global healthcare.

M-health in Bangladesh

The following section pertains to the development of m-health within Bangladesh. Due to the limited amount of literature on m-health within this country, only seven articles were used to discuss its overall progression. The following subject areas in which there has been collaboration with m-health technology in Bangladesh include: malaria, maternal healthcare, breast cancer, health helpline, immunization and lastly an in-depth look into a study focusing on CHW perspectives on BRAC's newly implemented m-health program.

With malaria being a common disease in Bangladesh, an m-health study was conducted in the Bandarban district, where malaria is endemic. At the time of the study, Prue *et al.*, (2013) were aware that there was a recent increase in mobile phone usage in Bandarban. Taking advantage of this resource, the researchers decided to see if mobile phones could improve malaria case detection and treatment. Although this study was part of a larger longitudinal study that was focused on malaria epidemiology, the researchers took this opportunity to observe the effects of m-health. In 2010, with 4,632 households identified and positioned, people with malaria symptoms had the option of either informing one of the twenty field workers, who made frequent visits to the communities, or calling them through mobile phones as the technology became available. Between 2011 and 2012 an additional survey was conducted on mobile phone use, to gain a better understanding of mobile technology ownership and access. The results from 2010 to 2012 showed 986 individual calls reporting malaria detection, causing 1046 people to be tested (often more than one person in the household was reported), and of those 265 (25%) tested positive for malaria. Consequently this accounted for 52% (265/509 cases overall) of all the

malaria cases identified. Data collected from the alternative survey found that 77.4% of the population had no access to phones. But even with the limited mobile phone ownership 52% of the overall detected cases were reported though mobile phones. Furthermore, from the initial mobile introduction in June 2010, till the end of the study in June 2012, the number of cases reported by mobile phone increased suggesting more reliance on for malaria reporting. Although the study showed promising benefits for malaria detection, it had several limitations. Generalizability was a large concern since the study took place in a community which had continuous research and monitoring, making this study an unsuitable representation of the general population. Another limitation was that the additional study assessing mobile phone ownership and access should have been carried out at baseline and at the end of the study, to provide an accurate account for any changes in mobile access.

The next study conducted by Akanda & Roknuzzaman (2013) focuses on the user opinions of the established D.Net organization. Being one of Bangladesh's largest ICT development organizations, it focuses on innovative programs to better assist rural communities. To show the efficacy of this organization, this case study identified all programs and services existing under the organization, assessed user opinions on each of the programs, measured the overall satisfaction levels of users for each program, as well as examining potential problems and proposing future recommendations. Taking into consideration the two programs that focus on m-health technology, Infolady and MAMA (Aponjon), the user opinions of effectiveness based on a five point Likert scale showed a mean score of 3.66 and 4.37 respectively. In recognition of the popularity of Infolady, a separate survey was used to determine the significance of the services it provides. Out of the thirteen services listed, support to pregnant women came up as the most significant service, with a mean score of 4.62, health check-up was fifth in significance with a mean score of 3.79 followed by vaccination with a mean score of 3.73. Focusing primarily on the

health services offered by Infolady, it could be assumed from the satisfaction levels that health services encompass the highest levels of significance in comparison to the other services it offers. Understanding that Infolady is a prevalent service of this type offered within the country, there is a general consensus that the population finds their health services to be highly effective. This ultimately brings value to the Infolady services. Although this study showed that D.Net has an overall positive impact on the Bangladeshi population, the study does have limitations. First the results were based on a relatively small sample of 120 participants. Furthermore the study was sampled in areas where program hubs were situated, making it vulnerable to biases as these populations have increased exposure to these D.Net services. Both of these qualities therefore contribute to the lack of external validity, which consequently reduces the generalizability of the study. Even with the extensive recommendations mentioned, which are beneficial for D.Net service development as well as m-health advancements in Bangladesh, there is still substantial need for program evaluation to address the impact health these services have on the local population.

In a recent RCT conducted by Ginsburg *et al.*, (2014), researchers initially found that families struggled with breast cancer care. If women were treated, it was with incomplete surgical incisions and no follow up sessions. By teaming up with a local organization called Amader Gram (Our Village), they were able to show how m-health technology could help bring awareness to breast health promotion as well as encouraging those with an abnormal clinical breast exam to attend a clinic. Based on an initial unpublished pilot study, Amader Gram was able to get a general understanding of the study methodology as well as to receive approval for m-health implementation from the district government. In conducting this three arm randomized controlled field intervention trial, CHWs were initially trained to use the mobile technology, to take informed consent, and to perform clinical breast examinations. They were then placed either in

Arm A (where a smart phone provided information and motivational videos as well as offered an appointment for women with abnormal CBE); Arm B (identical to Arm A, with the addition of "patient navigation training" in which the trained CHW would help guide the patient through any barriers); and Arm C (the control arm that consisted only of a paper based interview and no smartphone applications). After interviewing 22,337 women, the findings suggested that the CHWs with smartphones had higher adherence levels in comparison to the control, with Arm B having the highest due to the added benefit of a trained CHW guiding each individual. Within the control arm, there were fewer completed interviews along with poorer quality data, suggesting a smartphone application is an essential tool for promotion of breast care and increased clinical attendance for those with abnormal CBE. Although the study had methodological strengths, as mentioned by the authors, it failed to track the overall progress and diagnoses of the women that had abnormal CBEs. Although they had improved the adherence levels to clinical attendance, the general health outcomes should be considered in follow-up studies.

Studies discussed thus far have shown the potential and feasibility for m-health services within rural Bangladesh. In a cross sectional assessment study by Labrique *et al.*, (2012), that focused on mobile ownership and use amongst Bangladeshi rural women, it was reported that irrespective of phone ownership, 20% of all the women reported emergency health situations using a mobile phone. Of these, 85% actually owned a phone. As seen in the malaria study by Prue *et al.*, (2013) this assessment similarly suggests that the mobile phone has the ability to help populations during vulnerable situations even when ownership is not a critical factor.

The ability to have healthcare communication at your fingertips is essential in remote communities, especially when access to care is limited. A qualitative study by looked at individual accounts on a mobile help hotline intervention (Ashraf, *et al.*, 2010). This study was able to show how this service could cause overall changes in behaviour. Although the sample size

was small, the changes that were noted stemmed from the positive attitude that both doctors and patients had for this service. Patients overcame issues involving distance to medical facilities, unavailability of doctors and financial costs and were able to access information that improved their health outcomes. By supporting positive behavioural changes with m-health, this provides the initial steps towards the introduction of mobile technology in healthcare systems. As seen in the next section, BRAC is trying to tackle this, by understanding the general perceptions of ICT development within the Bangladeshi population.

The impact of BRAC's m-health pilot initiative in urban slums of Dhaka, Bangladesh

Maternal healthcare is getting more attention within the Bangladeshi population. With BRAC establishing the successful Manoshi project, which targets maternal neonatal and child health in urban slums, it has created a network of CHWs who identify pregnant women within their community through a door-to-door service (BRAC, 2014). Understandably, with such a large population, the ability to track every pregnant women is definitely a challenge. A pilot study conducted by Alam, *et al.*, (2010), studied how m-health technology could impact efficiency, cost benefit, usability, acceptability and value addition when CHWs identify pregnant women. The project was divided in to three parts: first creating the m-health technology for CHWs to use, then teaching them how to use the new application, and lastly evaluating its overall impact. The results proved that with m-health assistance, efficiency had increased as interview times had decreased from 30 minutes to approximately 4-6 minutes. The CHWs found that the technology was a simpler platform to use and was perceived as an acceptable data collection method. The potential cost benefit was estimated at 3.9% in savings, taking into account all the technical costs, as well as the reduced number of CHWs needed. One negative mentioned about this mobile intervention was its inability to provide real-time assistance and feedback to high-risk patients. However as

mentioned in the article, the technology has the capability for improvements that will help to better serve the population. The study had the limitation of being a small pilot study, with potential for bias due to the fact that the population was purposively selected. By targeting specific populations, it reduces the overall generalizability of the results. As mentioned, this study conducted by Alam *et al.*, (2010) primarily focuses on CHWs as opposed to the opinions of the developers as well as the end users, the villagers. This therefore is only representative of the opinions of one segment involved with the intervention. By expanding this study to include the different sources involved, as proposed within the scope of this research study, it can provide a comprehensive understanding BRAC's pilot m-health program implemented in Kunipara, an urban slum within the capital city Dhaka.

Most such studies had potential for m-health technology applications, specifically in regards to vulnerable communities within Bangladesh. These findings have the potential to be replicated in all developing countries. Although the impact of m-health appeared to be substantial, there is still the main limitation of literature credibility. Most of the published studies pertaining to m-health in Bangladesh come from non-accredited sources and involve many pilot studies. This indicates the need further research and publications within this field. Similarly the implications of having primarily pilot studies indicates a need for larger, nationally scaled approaches for m-health research understand how this technology can be best utilized and applied in developing countries.

Part IV: Methodology

Overview of Exploratory Case Study Design

The purpose of this study is to use collect and analyse participants' perspectives to define BRAC's newly implemented m-health technology and to understand how this service benefits them. By taking an in-depth look into the perspective of the three sources (BRAC developers, the CHWs and villagers) most involved with the m-health intervention, their perspectivres will provide an understanding of its overall impact. This exploratory case study is designed to understand the background literature and perceptions of the potential impact of using an m-health service within the urban slums in Dhaka. As mentioned by Yin, (2009) an exploratory case study is a qualitative research method, focusing on evaluating an intervention that has no defined outcomes. By understanding the outcomes from this study, the study can provide further assistance to the organization on its positive influence as well as the areas in need of improvement. Qualitative case studies are integral to understanding when the focus is on the "how" and "why" questions of an intervention and when subjects cannot be influenced by the researchers (Yin, 2009). Since this approach takes context into consideration, it is able to provide a holistic and true picture of the intervention (Baxter & Jack, 2008). Furthermore, with the limited knowledge on the outcomes of the intervention, the advantages of using exploratory research is that often generates new hypotheses for future study designs (Jaeger & Halliday. 1998; Marshall & Rossman, 1999). Considering the novelty of BRAC m-health service, this study design best fits these conditions, providing results that could initiate further research within this field.

Ethical Consideration

Ethics approval was granted from McMaster University, Faculty of Health Science Research Ethics Board for the proposed study in Bangladesh in May 2014.

Prior to data collection, participants were either provided with a package containing two copies of the consent form as well as an overview of the study, or participated in a verbal narration of the study purpose. The content of both consent methods (Appendix 1 and 2 respectively), informed the participants of the maintenance of participant confidentiality and the rights of participants to withdraw from the study at any time without any consequences. In addition to this, it also highlighted the study purpose and overview, brought attention to the fact that all those participating would encounter no harm or risks in the duration of the study and lastly informed participants that they had the choice to view the overall study results once completed. Participants were also informed that with the infancy of this pilot m-health initiative there is potential room for improvement, therefore receiving their feedback would be beneficial for providing future recommendations for developments within the program.

To ensure minimal risk for the participants involved, anonymity was strongly enforced. When collecting personal information all participants were provided identification numbers to prevent any association with their private information..

All hard copies of the consent form, questionnaires, and semi-structured interviews were kept anonymous by storing the documents in a locked location accessible only by the researcher during the study. Once the data from the questionnaires and semi-structured interviews were transcribed and collected on electronic files (Word documents, Excel spreadsheets, and Nvivo) all hard copies were shredded and discarded. These electronic files were stored on a personal password-protected computer with only researcher access. All audio-recorded files of the semi-structured interviews were also transferred from a locked audio recording device to the personal

password-protected computer with only researcher access. Once the data had been reviewed and analyzed, the researcher will kept the files for five years, and after this time, all files will be deleted from the personal password-protected computer and all hard copies of the consent forms will be shredded and discarded.

To maintain minimal risk for the researcher conducting the study, BRAC staff provided continuous assistance within the field. The navigation provided by them in finding the appropriate participants, communities and villages further helped minimalize any potential risks. Additionally the association with BRAC helped bring credibility to the researcher when conducting the interviews with the participants.

Study Sample

Recruiting Methods

With the infancy of the organization, the primary means in obtaining the participants was through direct contact with the program developers. In this case, the BRAC program developers were contacted through electronic mail, which included the directors and senior management staff of BRAC's health, nutrition and population programme (HNPP). After receiving agreement, meetings were scheduled with the BRAC staff member. Here discussions were held about the purpose of the study, the research question and objectives including the potential participants and the study settings. BRAC staff members were also able to provide appropriate direction to the communities and villages using the BRAC m-health service, as well as the participants who could take part in the study. These staff members were also asked to be included in the study sample.

According to Coyne (1997), there are many implications with sampling methods in qualitative research, whereby this type of definition oof each might be misinterpreted and overlapped with alternative definitions. of the types available and their definitions. Looking

specifically at purposeful sampling, Patton (1990) describes this form of qualitative sampling as using information-rich cases that can provide essential conclusions to the field of interest. Within this type of sampling, Patton (1990) includes snowball/chain sampling, which is described by Suri (2011) as finding information from the study participants/key informants about other sources of information-rich cases relating to the field of interest. As mentioned by Penrod, *et al.* (2003), this is an ideal method of sampling as it provides sufficient detailed accounts on specific topics that are offered in hard-to-reach populations. Keeping in mind that the BRAC m-health services are offered in urban slums within Dhaka, the snowball/chain sampling sampling technique is therefore appropriate for this environment. Consistent with the literature, snowball sampling was used to provide any additional sample participants that could contribute to the overall study findings.

Selection of Study Sample

Once study participants were identified they were interviewed including the BRAC m-health developers, the CHWs, (also known as Shastya Kormis (SK)) and the villagers. The participants could be any gender, above the age of 18, and those who had heard or used the BRAC m-health service.

Sample Size

Due to the exploratory study design, the sample size was dependent on the data quality and whether it achieved data saturation/redundancy and data triangulation. Data saturation/redundancy is the point at which no new information is found (Strauss & Corbin, 1998; Guyatt, *et al.* 2008). To achieve this, the objective is to obtain all the necessary information about the intervention from the participants until data saturation has been reached. Data triangulation is

the point at which there is an agreement between the combinations of data collected from two or more sources (Thurmond, 2004). In this study, once there was overlapping of data from multiple sources (BRAC developers, CHWs and villagers) data triangulation had been achieved. Within this exploratory study, the total number of participants interviewed to reach data saturation/redundancy and data triangulation was 21 participants, of whom 7 were BRAC developers, 7 were CHWs and 7 were villagers who had used the service.

Data Collection

In the process of data collection for an exploratory case study design, one of the major strengths comes from the use of multiple sources of evidence (Yin, 2009). Having the ability to capture data from multiple sources provides a more accurate representation of the intervention being studied. In order to achieve this, the study data sources and the data collection methods included the following:

1. Participant demographic data questionnaire provided to obtain a description workforce and educational backgrounds.
2. Semi-structured interviews with probes designed by the researcher to provide an in-depth look into participant perspectives and opinions of the m-health service

Demographic Data Questionnaire

The information gathered in the demographic data questionnaire includes the participant's age, gender, highest level of education, household resident numbers, occupation/livelihood, geographic accessibility to nearest aid (hospital, call-center, community health center), and mobile accessibility. Using the Demographic and Health Surveys (ICF International, 2011), this questionnaire was designed to gather workforce demographic data of the

study population. This concurrent procedure, where the study starts with a qualitative broad survey to generalize information about the demographic background and characteristics of the participants, which is then followed by a qualitative component to assemble a more detailed perspective from the participants, allows the researcher to converge different types of data to provide a comprehensive analysis of the phenomenon (Creswell, 2003).

Semi-Structured Interviews

This qualitative component is the most integral part in answering the main objectives of this study. It provides a solid understanding of BRAC's m-health service, and the perceptions and opinions surrounding the intervention. According to Yin (2009) a well-conducted interview incorporates an open-ended conversational style, all while gaining in-depth analyses from the interviewees about the focus of interest. Although conversational, the semi- structured interview allows the researcher to have some discretion in the way in which the questions are asked, therefore allowing for more in-depth and thorough answers (Harrell & Bradley, 2009). The interviews used a similar structural format across the board to gain a more collective set of responses (See Appendix 4, 5, and 6). The questions were divided into three different categories, which include *services; training and guidelines;* and *perspectives*, each of which were further sub-divided to address specific research objectives. Ensuring consistency between the study participants within these guidelines allows for easier data analysis and compilation of reoccurring themes. In order to stimulate interview questions, probes were used for each question, which elicits additional information when questions are not appropriately answered and further clarifies misunderstood responses (Harrell & Bradley, 2009).

During data collection, all 21 interviews were conducted in the participant's natural environment and were spoken in their native language: Bangla, by the researcher. This creates an

intimate perspective of the research setting, allowing the researcher to be more sensitive and aware of the data being collected (Mays & Pope, 1995). The interviews with the seven BRAC developers were conducted within the BRAC head office (2), and the Manoshi branch office (5). For the seven CHWs, interviews were held within the Manoshi community clinic (which was adjacent to the branch office) and lastly all seven villagers were interviewed within their own homes. Since all interviews were scheduled during work hours, this limited the availability of many villager interviews as the majority of them were out working.

The total length of the interviews ranged between twenty to forty minutes. To ensure accurate transcription and translation of participants' accounts, all interviews were digitally recorded with the addition of hand written notes. After completion of each interview, a debriefing session was provided to the participants. Here, participants were encouraged to ask questions about the study as well as offer their reflections about the overall content and practice.

Limitations of the study

Conducting semi-structured interviews can have limitations. According to Yin (2009) the content provided by interviewees in semi-structured interviews are verbal reports. Therefore they are vulnerable to weaknesses as they could include recall bias, response bias, and reflexivity. Reflexivity, which is referred to as social desirability bias by Grimm (2010) is when subjects respond with what the interviewer wants to hear; these are socially desirable responses, as opposed to truthful accounts. In order to prevent these biases from transpiring and to ensure validity is maintained, this study used the triangulation approach by which information is gathered from a range of independent sources (Mays & Pope, 1995). In this case, gaining perspectives from BRAC developers, CHWs, and the villagers provided a more rounded understanding. Another limitation is that interviewers may be susceptible to interviewer bias,

which is when any prejudice or opinion of the interviewer is reflected in the interview process, therefore influencing the data (Harrell & Bradley, 2009). As recommended by Harrell & Bradley (2009) to avert this bias, this case study was constructed using interview guidelines that maintain neutrality, by asking questions to participants in the same manner and covering the same topics.

Data Analysis

Demographic Questionnaires Analysis

All the responses from the demographic questionnaires were inputted and analysed using Microsoft Excel and Nvivo. The purpose of obtaining these data was to combine the qualitative data from the interview with the quantitative data from the questionnaire.

Semi-Structured Interview Analysis

In order to effectively analyze this data, two analysis techniques were used: *framework analysis* (Ritchie, Spencer & Connor, 2003) and *thematic analysis* (Braun & Clarke, 2006). Framework analysis involves six different steps: (1) familiarizing oneself to the data by noting down any initial themes or concepts, (2) generating a thematic framework where themes are categorized into sub-themes, (3) indexing the data (through terms or numbers) with the thematic framework, (4) sorting the data by themes into logical charts or tables, (5) developing the themes by adding descriptions and refining the categories, and (6) developing explanatory accounts, looking for patterns or associations (Silverman 2010). Within thematic analysis, there are five similar steps involved: (1) familiarizing oneself with the data, addressing any initial ideas and concepts, (2) generating initial codes systematically throughout the data, (3) searching for similar codes and combining them to make potential themes, (4) reviewing the themes to see if they relate to the data, and (5) refining the themes, finding appropriate propositions and linkages

between them (Silverman, 2010). Combining these analysis techniques, which use similar steps, represents the general guidelines to this analytic process.

In accordance to the initial steps in both analysis techniques, the researcher has to familiarize herself with the data, and in order to do this, the digitally recorded transcripts of the semi-structured interviews were transcribed and translated. According to Lapadat & Lindsay (1999) this is an *interpretive act,* where the initial comprehensive meaning of the data are formulated. After this a coding system was used, which is when data are critically assessed and conceptualized to generate concepts/themes (Strauss & Corbin, 1998). There are three main coding types which were used in this process in the following order: open coding; labeling and categorizing data into concepts and categories, axial coding; developing and connecting main categories and sub-categories, and lastly selective coding; integration of categories to form a theoretical framework (Pandit, 1996). To accompany the coding process, memos were also used to help manage and track categories, hypotheses and to generate questions; an important step in the research process that helps in the formulation of theory (Strauss & Corbin, 1990). The two types of memos involved include code memos that focus on the conceptual labeling, and theoretical memos that focus on the process of theory development (Pandit, 1996).

During the initial open coding method, the transcribed data were read through three times to get fully acquainted with the data and find potential codes. In order to maintain this data in a comprehensible and organized manner, NVivo 9.0 was used. This software, which enables researchers to manage their data, is a dominant choice in qualitative research. With built-in tools created for easy coding and construction of memos within the NVivo software has the ability to enhance efficiency, multiplicity and transparency within the research process (Hoover & Koerber, 2011). With the assistance of this software, the coding schemes were able to generate categories as well as narrow them down to significant themes. Additionally to verify the coding process, an

external research team was used to provide credibility to the findings. Two researchers independently created a coding scheme, and then these were compared and discussed with the researcher's coding scheme. Once differences were resolved, a final consensus was made regarding the main themes. By identifying these themes and then extrapolating the value of each in relation to the perspectives of m-health technologies, this data analysis methodology allowed for successful data interpretation.

Rigour

Rigour plays a significant part in case studies for two reasons. As suggested by Gibbert, Ruigrok & Wicki, (2008), first, case studies are the foundations for the construction of new theories; therefore any problems with rigour initially can create problems further down the line, especially when relationships and patterns are being tested. Secondly, with the intimate interaction with the participants, case studies provide a real representation of the management situation, therefore the methodology has to encompass knowledge that it relevant to this situation. As recommended by Gibbert, Ruigrok & Wicki, (2008) to ensure that rigour was maintained, the positivist tradition recognized by Cook and Campbell, (1979) was followed. This includes internal validity, construct validity, external validity and reliability. To ensure *internal validity* was maintained, which is when the researcher provides logical conclusions to defend the study (Gibbert, Ruigrok & Wicki, 2008), this study used theory triangulation whereby findings are interpreted by using different bodies of literature (Yin, 2009). Construct validity, which ensures that the measurement appropriately corresponds with the theoretical constructs (Hulley, 2007), was maintained by following data triangulation, which is when different sources of information are used to look at the same phenomenon (Guion, Diehl, McDonald, 2011). This was managed by collecting perspectives from the three main stakeholders of the m-health initiative: the BRAC

developers, the CHWs and the villagers. External validity, which is also referred to as *generalizability*, is the degree in which the results of the study can be applied in other settings (Hulley, 2007). Since this was a pilot intervention, this case study explores initial theme and concept developments. Therefore using a nested approach by using three types of cases (BRAC developers, CHWs and villagers) within one organization (Yin, 2009) provided a rationale for generalization (Gibbert, Ruigrok & Wicki, 2008). The last step involves reliability, which is the reproducibility of a study (Hulley, 2007). To ensure this, transparency and replication need to be established throughout the study (Gibbert, Ruigrok & Wicki, 2008). Study protocols that contained the overall study purpose and procedures, confirmed transparency; and replication was upheld through the storage and organization of all study material and data on NVivo, which could allow for later retrieval. In addition to this, written and electronic records of the coding schemes, as well as a chain of evidence were maintained throughout the study through NVivo, providing detailed accounts on the data analysis process, and by keeping records of all committee meetings, external research team discussions, the content discussed, and finally the draft submissions.

Part V: Data Findings

In this section the findings describe the overall perceptions of the m-health service implemented in the urban slums of Kunipara, as expressed by the BRAC developers, the CHWs, and the villagers. First the findings will focus on the description of the participant demographics, which will then be followed by a thorough content analysis of the semi-structured interviews. Using the participant narratives, within the content analysis, the data will be divided into two parts: first, it will describe and define all the facets of the m-health service understood by the participants, and second, it will highlight all the emerging and overlapping themes found within the content.

The demographics

One of the objectives was to describe the demographic characteristics of the participants. These data were collected on seven BRAC developers, seven CHWs and seven villagers. Although all the participants reside in Dhaka, when asked about their original district, there were a variety of different responses. Figure 6 captures where the participants have migrated from prior to coming to the capital city, Dhaka. This shows that migration is favoured from all areas of Bangladesh, as opposed to one specific area or district.

When looking at the BRAC developers there is a range of ages within their group, with the majority between 26-30 years (n=3, 42.66%), followed by 28.57% (n=2) between 31-35 years, and 14.29% (n=1) in both the age ranges between 36-40 years and between 41-45 years. Within the CHWs, there were 42.86% (n=3) between 18-25 years, followed by 28.57% (n=2) between 26-30, and 14.29% (n=1) in both the age ranges between 31-35 years and between 35-40

years. Villager ages were more concentrated towards the younger ages with the majority between 18-25 years (n=4, 57.14%), followed by 42.86% (n=3) between 26-30 years (see Table 2, Appendix 8). When observing the participants' highest level of education, all the BRAC developers had a university or higher degree. With the CHWs it is mandatory in their position to have received the secondary school certificate. There were 71.43% (n=5) who had received the certificate, and 28.57% (n=2) who had received the higher secondary school certificate. The villagers had lower levels of education, with 28.57% (n=2) having no educational background, 42.86% (n=3) receiving a primary school certificate and 28.57% (n=2) receiving a secondary school certificate (see Table 3, Appendix 8). All CHWs and villagers were women (see Table 4, Appendix 8), but within the BRAC developers 80.95% (n=17) were women and 19.05% (n=4) were men. Additionally, with the m-health service catering to MNCH predominantly more women were the beneficiaries of the service than men. Although men are aware of the service, it is only the women in the villages who had their data collected by the CHWs. Amongst the BRAC developers 57.14% (n=4) were men and 42.86% (n=3) who were women. When addressing the participants' occupation or livelihood, most were working within health services. With all the BRAC developers working within MNCH and the CHWs all working under the Manoshi program, there were 71.43% (n=17) of all participants working in the health sector. Within that percentage, one participant included a villager, who was temporarily on maternity leave from her role as a health worker. The remaining participants were all housewives (n=6, 28.57%), which was the predominant livelihood type for majority for the villagers (n=6, 85.71%) (See Table 5, Appendix 8). Table 6, in Appendix 8, shows the residents per household for each of the participants. Most participants had between 1-5 residents per house (n=19, 90.48%), with only two participants: one villager and one CHW having 6-10 residents per house (n=2, 9.52%). In addition to this, it was important to find out the number of participants who owned their own

mobile (Table 7, in Appendix 8). There were 90.48% (n=19) participants who had their own mobile device, and only 9.52% (n=2) who did not. This small percentage included two villagers. Although they did not have their own mobile phone, they stated that they had access to their husband's mobile phones.

The next set of tables (Table 8 to 11, in Appendix 8), address access to medical assistance. Specifically, for the nearest access to hospital care (Table 8), most BRAC developers responded with a different hospital, these include: Combined Military Hospital (n=1, 14.29%), Lab-aid Specialized Hospital (n=1, 14.29%), Apollo Hospital (n=1, 14.295), Uttara Hospital (n=1, 14.29%), and Dhaka Medical Hospital, the government hospital (n=3, 42.86%). Compared to the CHWs, who only mentioned two hospitals: Dhaka Medical Hospital (n=2, 28.57) and Ad-din Hospital (n=5, 71.42%). Similarly, the villagers mentioned using the same hospitals, with 57.14% (n=4) using Dhaka Medical Hospital and 42.86% (n=3) using Ad-din Hospital. In addition to knowing which hospital was their preference, it was also important to know the distance travelled by the participants to access these hospitals. The majority of the BRAC developers travelled larger distances to access hospital care with 42.86% (n=3) travelling 6-7km, followed by another 42.86% (n=3) travelling 7-8km and 14.29% (n=1) travelling over 8km. In contrast, within the CHWs, the majority travelled 2-3km (n=6, 85.71%), and only 14.29% (n=1) travelled 5-6km. Similarly, for the villagers, there were 42.86% (n=3) who travelled 2-3km and 57.14% (n=4) who traveled 5-6km (See Table 9). With these distances, it is assumed that all participants used a mode of transportation to reach these hospitals. With the community centers (the branch center and the delivery center) offered to the villagers, it was also important to find the distance travelled by them. Since these are located within the slum, all villagers are expected to walk to these locations. Table 10 shows that two villagers mentioned attending the branch center (28.57%) and five mentioned attending the delivery centers (71.43%). For some of these

villagers it would require a 0.2-0.3km walk (n=3, 42.86%), a 0.4-0.5km walk (n=3, 42.86%) or a 0.6-0.7km walk (n=1, 14.29%).

In summary, the demographic data indicates the differences between the BRAC developers, the CHWs and the villagers. The BRAC developers encompass a wider range of ages, with a mixture of genders and higher levels of education. In comparison the CHWs and the villagers encompass a younger age group of women, with the CHWs primarily having received their secondary or the higher secondary certificate, and the villagers receiving none to minimal levels of education. For access to medical facilities, it can be assumed that the BRAC developers have the choice to attend hospitals of their preference; this is demonstrated by the fact that they are willing to travel longer distances. In contrast however, when looking at the limited responses offered by the CHWs and the villagers, in terms of hospital care, there is a lack of choice. With the m-health service offering individuals referrals to specific hospitals, there is a limitation on where the CHWs and most importantly where the villagers can go to receive hospital care. These selected hospitals could be due to their organizational affiliations, or due to their overall close proximity to the urban slums. By capturing the demographic data, this provides the quantitative understanding of the study sample, which can complement the participants' perspectives discussed in the following section.

Content Analysis: Semi-Structured Interviews

Within this section of the data analysis, the purpose is to explore and describe the perceptions of the newly implemented m-health service (Semi-structured interview guide found in Appendix 4, 5, and 6). By using narratives gathered from the BRAC developers, the CHWs and the villagers, this analysis first focuses on defining the m-health service. This includes the roles and responsibilities of the CHWs, the smartphone application, the program support that exists for

the program, and lastly the description of the call center. The second part of the analysis reviews the underlying themes that exist between the information provided by all three classes of participants. This method of triangulation where different sources of information are used to focus on the same phenomenon (Guion, Diehl, McDonald, 2011) is able to highlight these emerging themes, bringing agreement to, as well as cross validating the study findings (Thurmond, 2004). The themes being discussed include (a) the strengths and benefits, (b) knowledge of the service, (d) challenges and barriers, and finally (e) areas of improvement.

The M-health Service Description

The following section provides a detailed description of the m-health services through the lens of the participants. It describes both the background and the day-to-day process involved with the service. The multiple facts of the m-health service will be discussed, including detailed accounts of the roles and responsibilities of the CHWs; the description of the smartphone application; the description of the call center; and lastly the program support that exists within m-health service.

Roles and responsibilities

Apart from using the smartphone application, which is the focal point of this study, it is essential to understand the roles and responsibilities of the CHWs within their communities. The semi-structured interview guide (Appendix 4, 5, 6) asks questions regarding the CHWs day-to-day schedule, their reach within the community, their mode of contact and the common community concerns. These areas of focus will be discussed, as described by the participants.

CHW Daily Routine

As previously mentioned, the CHWs, who are referred to as SKs during the interviews, have SSs working under them. These SSs, who are volunteers, work alongside the CHWs and collectively they are responsible for providing MNCH through a door-to-door service. As described by one CHW, their daily routine consists of:

> "First we go to collect our registers from the branch office, or the delivery centers. Then we write down the name of which SS we are working with - we usually get out by eight – eight ten, then I go to the SSs house. Then over there she has her own register, which says which households we have to go to, and with all this, and the SS, we then head out."

This description of their routines is shared amongst the majority of the CHWs, whereby each CHW understands that they have the responsibility of meeting the SSs at their homes, checking their registers for the community households' visits, and then proceeding on to the field. The BRAC developers understand this routine, knowing exactly what is expected in the CHWs, and how it is executed within their daily routine. As mentioned by one of the BRAC developers:

> "They go to different households, whichever ones they are meant to for the day. In one book they have information on 200 households, which they divide by 4. In that, let's say they visit 40, if in those there are any problems and concerns with their health they record it."

Similarly this routine is experienced on the receiving end, whereby villagers know that they will be expecting visits from the CHWs:

> "They always call to check in on us. Every month they come to visit us, if not every few days."

Apart from the CHWs, the community and the BRAC developers were well informed about the routine of the CHWs. Additionally, the villagers were also aware of the fact that these door-to-door household visits give them an opportunity to share any of their health concerns with the CHWs. This routine therefore allows the CHWs to evenly space out their household visits,

ensuring that there is equal coverage of the community households. This is explained further in the next section.

CHW Coverage

The urban slum of Kunipara has a total population of approximately 50,000 people, which is equivalent to roughly 17,000 households. With this large population, the CHWs need to ensure that the households are divided accordingly. With CHWs having responsibility over 8 to 10 SSs, who each attend to 200 households, the CHWs cover approximately 1800 to 2000 households each. This population has to be divided within their schedule to ensure equal coverage. The 200 household coverage by the SSs is confirmed by one of the BRAC developers:

> "We have our SS that work for us in the program, she has 200 households that she works with. That is around a 1000 population in total that she works with. Every day she visits 10 of these households."

Keeping in mind that the registers belong to the SSs, this CHW describes how the households are evenly divided:

> "In one register there can be 200 households, or 400 households there could be 300 households - and with that we have to make sure we visit all of them in 4 months - as going to 200 in one day is not possible. Looking at it in one day there could be around 35 visits, so these 35, I will see in them in another 4 months."

This division of labor between the CHWs and SSs therefore ensures that the entire population is attended to for any maternal, neonatal or child healthcare. By dividing the population accordingly, there are specific CHWs and SSs for specific populations. This allows the community to be aware of their primary contacts when any issues or concerns arise. As described in the following section, the ability for the community to contact their primary contacts, the CHWs, is a crucial component when attempting to address any health concerns.

Getting in contact with the CHWs

In addition to the regular CHW community household visits, for times of immediate assistance the CHWs also ensure that they provide contact numbers to each of their clients. This ensures that the community has contact with them outside of their visiting times. This standard method of providing primary contact details to the community is shared between all sources. This guarantees that, if there are any concerns, questions or concerns, each individual is aware of how and who to contact. A BRAC developer further describes this:

> "The CHWs provide their cell numbers of their own, as well as their supervisors - program organizers (PO), to the households. During antenatal visits we provide a sticker containing the telephone phone numbers so that in case of any problem or any kind of demand, the community can call the SKs or the POs at any time."

In accord with this, the CHWs know that they are the ones responsible for providing this information to the community. This responsibility is demonstrated by a CHW when she stated:

> "When we give them the card, we give our phone numbers there, the POs number is there, my number is there, we give the service center number, the call center number. Then if they need something - if they have any problems they can also give the call center a call, then they ask for me."

On the receiving end, the individuals in the community know that they can use the contact information provided to communicate during an emergency situation, or for any general concerns. As mentioned by one of the villagers:

> "Yes, I call them, they gave me their number on the card and they also have my number too. And if I have any problems I give them a call right away"

There is a common understanding between all sources that each individual is provided with informative material, which includes either a card or a sticker. These contain contact information of the CHWs, the POs, or the call center. This reassures the community that they have easy access to the phone numbers, enabling them to always have someone to contact when a problem arises.

This development is a change in comparison to what previously existed. As described by a BRAC developer:

> "Previously it was that they have to…well there was two ways of contact, one was regular. That means that when health workers have scheduled visits to their households, and the second one is emergency where they have to go directly to the health workers house. But now they can call them."

Having the added benefit of calling on a mobile phone allows the end user to get immediate remote assistance and advice, as opposed to having to wait for CHW appointments, or physically having to visit the CHWs in their individual homes. Depending on the severity of the problem, the CHW, the PO, or the call center can provide appropriate feedback through phone conversations without any major delays.

Common Community Concerns

With the instant feedback provided by the CHWs, the PO and the call center, it is important to know the most frequent use of the service, specifically the most common problems that are called in by from the community. With problems mostly associated with MNCH, it was common to hear that villagers called in for abdominal pains, vomiting and labor pains. As described by one of the BRAC developers:

> "Most of the time during pregnancy, it depends on the status of the women and children. During pregnancy, usually they complain about the complications like vomiting or abdominal pain, or fever."

Similarly this is mentioned by one of the CHWs in the excerpt below:

> "There can be many problems - it can be labor pain, it can also be that they are vomiting. All different pregnancy problems can happen."

From the villagers account, they also parallel these aforementioned problems:

> "If anything I get stomachaches - which they tell me to get checkups for. Then they check up on us after, to see if everything is okay. They check my pressure and everything."

In addition to the frequently stated pregnancy related problems, two CHWs also mentioned that often mothers would ask for advice on family planning treatment methods. One CHW describes below:

> "Majority is about family planning - which treatment do I use for me, which one will be good for me, if I have a small child at home, what is the best treatment? These are the questions they ask."

Similarly, another CHW describes:

> "If it's a family planning area - whenever they see me they ask me how I am doing, and then ask me that - my treatment is giving me problems what do I do"

Other problems that were also mentioned include the care of the child after delivery. As described by a BRAC developer, infants under the age of five are also entitled to receive medical attention from this service. This BRAC developer states:

> "We also work with their children under the age of five - if they have any problems such as pneumonia, diarrhea or any problems they have. Now we have started the 6-month complimentary feeding with everyone. We tell him or her that when their child reaches this age they have to be fed the mother's milk alongside mashed up homemade food. And if they have any problems or contradictions they can call us to get clarification."

This is an option that is offered, as confirmed by one of the villagers:

> "I called during a delivery - whenever there was a problem I would ask about it. Even after delivery if there were a problem I would ask. If there were a problem with my child I would ask what to take, to make it better and so forth."

The range of issues covered within this service is exemplified by the variety of questions and concerns requested by the community. As described in the literature, the findings suggests that the m-health service accurately represents all the objectives of MNCH, covering issues that involve pre-pregnancy, (which include family planning treatment methods); during pregnancy,

(which includes any problems or concerns with the mother-to-be); and post pregnancy, (which includes the care of child). Ultimately with these various problems, it is the responsibility of the CHW to provide the appropriate solutions.

The referral process

The referral process is one of the CHW's responsibilities. The CHW makes the decision to send aid to the patients, or to send the patient to the appropriate level of assistance at any time, depending on the severity of the problem. Previously, this referral process was only possible during the household visits as explained by one of the BRAC developers:

> "The job that we did manually referring SS or SKs - if there is any complications or problems where we would have to refer, we have to be physically be there or find a way to do that. But with this service, when there are any complications or any problems, there is the convenience for the people."

Now, the CHW has the ability to send for medical assistance if necessary. As described by one of the CHWs, apart from visiting the patient themselves they can also send out an SS to attend to the patient:

> "Let's say a mother has a problem and they call us, and it's not our office time, we are at home, and they call us. So what we do is we go there, or there are SSs, so we give them a call, they come and see the patient."

This is confirmed by one of the villagers:

> "If they can't understand it over the phone they come to my house to help me."

Additionally, the CHW can decide to send the patient to the delivery or branch center where there is a doctor available to provide medical attention. As described by one of the CHWs:

> "If there is a problem I send them to the maternal center where we have doctors - I try to do as much as I can - but send them there if I can't."

She further elaborates:

> "Well when they call me with a problem, I tell them go to the maternal center. There is a doctor there. I'm usually on the field, so I see them too, and then if there is a problem I send them to the doctor - I refer them.

When complicated cases arise, the CHW also has the ability to refer patients directly to hospitals by making arrangements with stationed POs. This is explained by one of the BRAC developers in the following excerpt:

> "We have referral program organizer, who is stationed in the functional facilities 24 hours. They have a roster duty, and they have a phone, so the community can directly call the referral center PO, or they can call the CHW. The CHW can call the referral center PO and say, see I have a complicated case here so please arrange a date, and plan for her, and attend the patient from here to the hospital."

This is confirmed by one of the CHWs:

> "We refer them to the hospital, they also know that we will send them there - we have contact with them too."

All of these arrangements are put into place by the CHWs, so patients know that they can rely on these authorities to take care of them. The role of the CHWs therefore encompasses a wide range of responsibilities. Apart from being the initial point of contact, they also have the authority to direct patients through the appropriate referral process to ensure that the patients' needs are attended to precisely and immediately.

The description of the smartphone application

The smartphone application is the newest addition to the m-health service; furthermore it is the central component within this research study. It is therefore essential to understand the elements that make up the service, as well as its place within the m-health service delivery. Within this section of the data findings, the following will be described: the infancy of the service, the content collected within the application, the data classification system, the data

collection process, the training procedures, and lastly the monitoring and evaluation for this service.

Infancy of the smartphone application

Being a pilot initiative, the smartphone application is still in its preliminary stages whereby the efficacy of the tool is being tested by the program developers. With many components still under development, the overall effects of the tool are still not widely experienced. As mentioned by a BRAC developer:

> "The platform is now developing, so it is not that much commonly used, only 34 SKs from urban slums are using this platform. And the software is getting developed, it's going on, testing from BRAC - fixing is still going on"

Similarly another BRAC developer mentions the infancy of this tool:

> "The mobile hasn't been around for very long, it's only been here for a few months, and within these few months there were some problems.

When asked how many months it has been around:

> "Only three months - but they haven't fully completed the whole thing yet."

Additionally a CHW confirms that they have only been using it for a short period of time:

> "Overall I've been using this new phone for 3 months"

It is clear, that this smartphone application is in its early stages of development. With only three months since the initiation of this service, the CHWs are still familiarizing themselves with its overall application. Moreover this tool itself is still restricted to specific locations, as mentioned by another BRAC developer:

> "Well right now it's only in this area that we are offering it - so only the Kunipara population is getting access. Now it's just our population - it hasn't spread that broadly yet – it's still just our population"

With the idea of this smartphone application launching in 2009, it was initially piloted in Badha, another slum within the capital city: Dhaka. As described by one of the BRAC developers:

> "It launched in 2009 in December - piloting in December. It was first done in Badha then it was done here. When I started in December - which was around the time it launched in Badha, they sent me to get familiar with the service but then it was brand new. There was a survey going on then on what information should be collected what mothers we would be focusing on – that's it."

Although initiated in 2009, the aforementioned excerpt shows that there were only surveys being conducted at that time to understand what components were necessary for the data collection process. Specifically looking at Kunipara, this initial smartphone data collection tool was only implemented within the last few months, reinforcing the infancy of the smartphone application. Furthermore it is important to note that while transitioning to a fully mobile service, the CHWs are still using both the smartphone application as well as their previously existing registries to collect data from the individual households.

The content collected within the application

Although the smartphone application is brand new, the elements that exist within the application are widely understood among all the CHWs. It is the responsibility of the CHWs during each household visit, to use the application for collecting data on the individual households, looking specifically at antenatal care (ANC), post natal care (PNC) and family planning methods. As described by one of the BRAC developers the following occurs during a household visit when the smartphone application is being used:

> "First of all they make a household registration, households' names, number of beneficiaries, age, if there is pregnant female she will be registered as pregnant, then she will provide ANC. And if she is not pregnant she will ask about family planning history - whether they are using, which kind of family planning methods and from where you are getting the methods. Such as if you are using pill, who is providing it BRAC or the government. So if yes, they are collecting from

> government, there is a drop down menu so you can choose yes from the government."

This is the consistent with the description provided by the CHW:

> "We ask about family planning - so who's taking what treatment or pill - this is what we ask - and if in these households there is a pregnant mother, for her we give a check up, we check her blood, her pressure, we take all the appropriate measurements. If there is a new mom, someone that just delivered, this is the PNC visit - so we give these new moms follow up visits."

There is common agreement between all CHWs and most BRAC developers on the content collected within the smartphone application. Furthermore there is common agreement between the CHWs and BRAC developers on the data collected after specifically identifying a pregnant women. As mentioned by one of the CHWs:

> "We check if there's any pregnant ladies, and we do a checkup for them, we check their vitals, then jaundice, we do a stomach test - so we do this all in our books and then the mobile as well.

Similarly a BRAC developer mentions:

> "Whether she is a pregnant mother - they will give antenatal checkups - antenatal visits to those mothers. And they will record the data on ANC (ante-natal care) visits information, like they will measure blood pressure, check up everything – jaundice, and they put this up in the software."

This exemplifies that there is consistency and standards in place when data are collected by the CHWs.

Apart from this data collected, it is also the responsibility of the CHW to create a personal profile for each woman they attend to; inputting and collecting data according to the responses made from the questions asked by the CHWs. To ensure accurate identification, this profile is accompanied with a personal ID number, as well as a picture of the individual women which are taken by the CHW on her smartphone. The CHW describes this process:

> "When we go to family planning, we talk to people there and ask them their names. We write it in the register, then from the register we talk to them about

> what method they are using - because they won't understand what family planning is - so what method are you using, what do you eat, what do you do? When they answer we add in our mobiles, we tell them we were given mobiles for this and to take pictures of you. After telling them we take the picture and whatever they answered for the method we put it in here."

This is procedure is also expressed by one of the BRAC developers:

> "Name, age group, taking pictures, the mothers problems that are coming up. When they turn it on, right away one mother's profile comes up by her name, but they have it with ID numbers. When they press the ID number, the mother's full profile comes up."

Having these individual profiles with ID numbers and photo identification allows the CHW to accurately identify the women within the community, as opposed to just relying on the names written within the registers. Most importantly, however, is the fact that the data collected by the CHWs create detailed accounts on each individual's family planning methods, their ANC or their PNC. As mentioned in the next section, the detailed profile, allow the individual women to be classified according to their risk level.

The data classification system

The ability to have profiles provides the CHWs with detailed accounts on their patients. Furthermore in times of emergency patients can be categorized based on their severity. As the CHWs collect the responses from the women, they are automatically pooled into specific groups based on their risk level. This process of classification is described by one of the BRAC developers:

> "Let's say there are 100 pregnant females that one SK has, if there are any high risks out of those mothers, they will not have to say. The SKs will not have to say that they are high-risk mothers, because the data will tell them how many high-risk mothers there are in this area. The indicators that we have [are] fixed, from there we are getting the data for the high-risks. There are nine to eleven sign symptoms, if they have this that means it is high-risk. We can separate the high-

> risk mothers, the normal mothers we can separate them all. The high-risk, where she can go to get the best treatment, we can also inform them."

Similarly another BRAC developer briefly states:

> "They are categorized depending on the answers, if they are high risk, low risk medium risk. Whatever they press that's how they do it – that's how they enter the data."

Although the BRAC developers only mentioned this component of the smartphone application, it can be identified as one of the objectives of the software. By identifying the high-risk patients, the CHWs, as well as the medical professionals can provide the appropriate medical attention.

The data collection process

Another objective of the smartphone application is to replicate the content collected in the registers. As mentioned by BRAC developers this data collection process replaces the original register (which included physically writing responses), with the smartphone application, (which relied on selecting options from a drop-down menu and inputting data electronically). Currently both the smartphone application and the registries are being used, with the intent to transition to the smartphone application. As described by one of the BRAC developers the smartphone application does the following:

> "At every house, the data that we used to collect in our registers have been replaced by mobile. Now instead of having pen and pencil to write with, she takes the verbal talk or she can type and record in all the subjects."

Alike to this, another BRAC developer reinstates this fact:

> "But for data collection and other services - I guess it is similar to the register when health workers were maintaining the register and now when the health workers are carrying mobiles – it is all the same for them.

Although only the BRAC developers once again share this idea, the overall intent is for the CHWs to use the smartphone service to replicate what was initially recorded within the registers. As mentioned in the excerpt below by a BRAC developer, the ability to have all the data inputted via the smartphone application allows for faster calculations that can be observed by higher authority.

> "When they are using the paper based system, so they need much more time to write, to calculate everything, so when they come to this form they are just collecting the data. There are automatic calculations and from our head office we can check this web-based platform so it is quite easy for them to collect data."

The data collection process of this smartphone application is ultimately to create a web-based platform that contains information on all individuals within the community. By having one platform, as opposed to multiple registers belonging to different CHWs, the information can be viewed and checked from one place. As mentioned in the monitoring and evaluation section, this helps obtain real-time data on the content collected on the field.

Training Procedures

With a novel device implemented within an urban slum, it is necessary that all CHWs get trained to use this new technology. When discussing the training procedures with the CHWs and the BRAC developers there was general agreement on the training methods, understanding that it is an important factor prior to its use on the field. Initially the training session will be discussed where the CHWs are introduced to the smartphone application, followed by the refresher-training sessions that are offered after.

Training Session:

When introducing a novel technology that replaces a manual system, there are changes that are experienced from all levels of authority. As described by one of the BRAC developers, this initiative was a collective learning process that involved external expertise:

> "We are also new, we are learning, so we are not experts, so we have made partnership with MPower. And they have some experience in this field, so they have the - they developed the training manual, and they provided the training. We have provided the management support but all technical support has been provided by them."

As aforementioned, the training was provided through an external source, whereby both the BRAC developers as well as the CHWs were taught about the mechanics of the smartphone application. As mentioned by another BRAC developer

> "We trained the 34 SKs about the smart phones, about the software everything, about some troubleshooting, how to troubleshoot any kind of problem they face. And moreover, we have some field POs who are responsible for any troubleshooting they face.

An integral element that was shared between both the BRAC developers and the CHWs was the practical component of the training procedure. As mentioned by one of the CHWs:

> "They introduced us to which software we would be using. The first day that we went they gave the phone in our hands and taught us how to use it - how to open and lock the phone and then which software we would use. For the work that we are doing on the software - how would we go in and use the phone to help us collect this."

Similarly to this, a BRAC developer comments on this method of training:

> "This is where I was practically shown how to write in the household, how to write the IDs, for medium risk, how we are supposed to enter it. They do it with their own hands - I think the term is "practical," that is the way they taught them."

Additionally within this training session, the CHWs are encouraged to participate in scenarios where they reenact a household visit using the smartphone application. This demonstration

therefore allows the CHW to become familiar with the device. Furthermore, they use this demonstration to show how the data are viewed instantly. A BRAC developer describes this demonstration:

> "They are given a demonstration - instant demonstration. They are given scenarios where they designate them - you two are mothers, you are two mothers and you are two mother and now show us how you would carry out ANC visits. Then instantly we show on the projector, such as Nasreen, a SK, Nasreen meets with one of the mothers on an ANC visit and collects and sends in the data. It then instantly comes up and we can see it on projector right away. We then tell show them how the data that they collected can be seen right away. We tell them, that what work you did or didn't do we can now see right away. This is the instant type of training that we do."

Although there were discrepancies between the CHWs on the number of days in training, a BRAC developer confirmed that:

> "It really depends on them."

This training procedure therefore is adjusted according to the individual CHW, ensuring that they are comfortable using the application. In addition to this, the trainers encourage the CHWs to provide their own feedback to prevent any complications when it is implemented on the field. As discussed in the next section, there are also refresher-training sessions that are offered after implementation, to help familiarize the CHWs with the application functions and discuss any potential complications.

Refresher-Training Sessions:

Apart from the initial training sessions, refresher-training sessions are also incorporated in the learning process. With the infancy of this program, these refresher-training sessions have occurred on a monthly basis, which results to approximately three group sessions for all CHWs. As previously mentioned, these sessions give the CHWs an opportunity to discuss any

complications and concerns that arise when using the device on the field. As described by a BRAC developer:

> "With every single individual we have a refreshers course every month. Refreshers training are held every month to address their difficulties and challenges. They come here and tell us the details."

Having a feedback system where the CHWs share their experiences of using the smartphone application informs the application developers on exactly what they have to do to improve the technology. As described by one of the BRAC developers, the CHWs are sent into the field with the smartphone application for the duration of a month. Within this month, they are encouraged to note down all the complications and problems they had faced during this time. After a month, the CHWs, trainers and some of the BRAC developers come together to discuss all the problems as well as the overall results. Additionally at this point the trainers examine the CHW's data collection errors, providing potential explanations for these faults. After this, the feedback that is provided by the CHWs is taken back and resolved accordingly. The trainers then return on another date for a refresher-training session, whereby all CHWs are called in, to introduce new changes. As described by the BRAC developer:

> "They are all then told to be called in. We tell them, the problems they had mentioned that day - those problems in the software, we have completed and fixed. That old software that existed, we will delete and give you the new software."

These refresher-training sessions inform the CHWs of all the new things that are added to the smartphone application. This is reiterated by one of the CHWs:

> "Well whenever there is something new - they call us in right away and train us about it, without the training I wouldn't know about these new things."

The refresher-training sessions are therefore an important part of the training process. Within these sessions, individuals can share their experiences and challenges and can expect that their feedback will be acknowledged when the software is updated. Once this is followed through, the

software is reintroduced to the CHWs, and the feedback system is once again restarted. This continues until the number of potential problems decreases overall to an acceptable level.

Monitoring and Evaluation

Many of the problems that arise with the smartphone applications are due to the negligence of the CHWs. To ensure that this is kept to a minimum, certain methods are used to monitor the CHWs; these include the real-time tracking abilities on the smartphone application, and the physical supervision that is carried out by higher-level authorities.

Real-time tracking:

One of the major components of this smartphone application is the real-time tracking that monitors the work carried out by the CHWs. When the CHW collects information about a specific household, this information is delivered to the BRAC server where it can be viewed by higher-level authorities, enabling real-time monitoring. As mentioned by one of the BRAC developers:

> "Now we have the convenience to see if they did the work or didn't do the work. I can get the data right here"

Similarly the CHWs are aware that all the information collected can be viewed instantly. As described below by a CHW:

> "Well the data that we collect is saved - so they can see exactly what we do."

As described, there is common agreement on the capabilities of this real-time monitoring feature. By receiving individual branch reports, each branch is able to gather the details regarding the CHWs work day, which includes where the CHWs are collecting data and what they are collecting. As described by a BRAC developer:

> "They get a sheet with all the information, so when they [CHWs] save the data it goes to the server. So let's say they gave service to 20 out 40 households, but they couldn't do 20, a sheet would come in later on letting them know that this SK didn't follow up with those 20 households.

The CHWs are well informed about the tracking ability, as mentioned by one of the CHWs:

> "Another good thing is sometimes when I'm working in this area I'm working in the Bagaan Bari (name of an area), the location comes up so people can know which area I'm working in - to see if I'm actually working or not."

Prior to this, to ensure that CHWs were physically present during these household visits they would have to either provide a voice recording of the woman in the household, or provide a picture. A BRAC developer reinstates this:

> "Earlier before that, she will have voice recording of the mother so we can just say yes she went to the house and talked to the mother. And also we had a segment, where she can take a photo and upload to the server so that we can know yes she visited the mother as well."

By having these new monitoring abilities, regional managers and branch managers can use these reports to easily follow the CHWs work schedule. This method therefore eliminates the need to physically monitor the CHWs' whereabouts. As mentioned by one of the BRAC developers:

> "With the monitoring system I can find right away and ask that in this branch why is this SK not doing her work? Otherwise for me to go visit every SK it is impossible. I can inform the branch manager right away - that these many numbers of SKs are not working why? What is the reason?"

Additionally, as mentioned by some of the BRAC developers, the ability to monitor the content collected by the CHWs allows for increased speed of collection and accuracy. This is described by one of the BRAC developers:

> "We are going to use the smart phones because it is much faster and the data is more accurately collected and which can be monitored anytime from anywhere."

The capabilities of a smartphone application can ultimately simplify the entire monitoring procedure. As explained by one of the BRAC developers, the intention is to create an application

that allows managers to monitor their CHWs from their desk continuously. The BRAC developer elaborates further:

> "We haven't started yet the monitoring system. It will be, it is part of our plan. There is GPS in every mobile phone. We know their catchment area, their working area, so if a manager can, when a manager sits in front of his PC, he can see what, which SK is working, where, and because data will be sent continuously he can't monitor from where the data has been sent - Is it from home or from the community."

With upgrades being made to the monitoring features, there are still older methods of supervision in place. These are conducted by the CHWs' superiors. As discussed in the next section, supervision from higher-level authority is still a common practice for monitoring the CHWs daily routine.

Supervision:

The CHWs still rely on physical supervision when they are out in the field. As described by the majority of CHWs, the PO, the branch manager and the regional manager continue to monitor CHWs. This traditional method, of accompanying the CHWs on the field, allows the POs or other levels of authority to oversee that their CHWs are conducting their daily routines accurately. As described by one of the BRAC developers:

> "We also have visits. When SKs are going the households, we also go too. We talk the SS too, to see where the SKs have taken them - which households. The SKs usually have SS with them. Sometimes we go along with them too - to see their movement and how they are monitoring, are they doing their work well and correctly."

This is confirmed by the CHWs themselves whereby they expect that they will be chaperoned. As reported by one of the CHWs:

> "Today she might go with me, and sometimes she might go with someone else - it really depends. Even with our phones, they make sure that we have the right program, that we have the right date, that we have money on the phone, they make sure everything is okay with the phone before we go out on the field."

Although the smartphone is potentially capable of monitoring CHWs remotely, the technology is still under development and yet to be implemented at the CHW level. This therefore suggests that the POs, the branch manager and the regional manager are still responsible for overlooking the CHWs duties, until the real-time monitoring technology is fully developed and integrated within the system.

Program Support

As previously mentioned, the POs, the branch manager and the regional manager are responsible for monitoring the CHWs during their daily tasks, but along with this responsibility, the POs, the branch manager and the regional manager are also linked according to their responsibilities within a chain of authority. As described in this section, these levels of authority assist the CHW when they are unable to solve a problem. These problems are categorized below as medical assistance, which includes support regarding health decisions; and technical assistance, which includes support regarding the m-health technology.

Medical Assistance

With basic medical training, the CHWs are able to address many of the concerns that arise within the community. However, certain circumstances require further attention and this is when the CHWs rely on their superiors for assistance. As suggested by one of the BRAC developers, starting from the SS, the following describes the chain of authority that exists when a problem needs to be correctly addressed:

> "Well let's say an SS comes across a problem, where she goes to a house and there is mother bleeding, or any such problem - the SS can't really do anything. They then call the SK, explain that this mother is having this problem. Then the SK goes to that mother. The SK then calls and informs the PO. If the PO thinks it essential, then they'll obviously go if it's very severe. If it's normal, where there is only a stomach ache, the SK can easily refer it to Dhaka Medical.

From the perspectives of the CHWs, there was a common finding that they would call and communicate to the midwives, the medical officers, or the POs about any current problems. With some of the facilities equipped with these staff members, a CHW can easily contact them on her mobile to find an applicable solution. As described by a CHW:

> "If I can't understand the problem, the people that are here, the manoshi mid-wives are here, I get in contact with them or I send them to go to that place. I also talk to the PO sister about it too. So if I can't figure it out, I call them try and figure it out, if not I send them here or I send them to the hospital."

By having this option available to them, the CHWs are able to find immediate solutions for the patient. Additionally the villagers expressed this finding, as they are aware of the fact that the CHWs can ask for assistance from higher levels of authority when they were unable to solve the problem themselves. As recalled by one of the villagers:

> "Yes they contact other people, they call the PO when they have problems to help them find out what to do"

Furthermore, as expressed by many of the villagers, if the problem is high-risk and the CHW is unable to attend to it, it is common for them to immediately refer the patient to a doctor or the hospital. Overall therefore, all sources are aware of the authorities that exist, recognizing where and who to go to when a problem cannot be solved. Since the CHWs are the first point of contact for most of the community, they are the ones accountable for contacting the appropriate levels of authority for assistance.

Technical assistance

In addition to the health support that is provided by the BRAC staff members, there is often need of technical assistance when something goes wrong with the overall m-health technology. As described by the BRAC developers and the CHWs, often when there are issues

concerning the m-health service delivery, there is another chain of authority in place to address these concerns. As stated by a BRAC developer, the following occurs:

> "If they find that the problem is within the community, that they can't solve it - the SKs give the POs a ring. They then try to solve it; if they cannot then they tell the branch manager. If the branch manager can't fix it then they contact the regional manager. If they can't fix it then they speak to the program manager"

This clearly identifies the level of authority that exists within the program. When there are questions or concerns specifically surrounding the smartphone application, the CHWs are told to contact the POs, however they are also encouraged to call the trainers themselves. When asked about the contact methods for these trainers, this CHW replied:

> "They gave us their contact numbers - if there are any problems or if we do not understand the work or something is not sending - what should happen here, how do I understand it - they tell us how to solve it."

Depending on the issues that are raised, whether it is in regards to the overall m-health service, or the smartphone technology, the CHW know exactly whom to contact when a problem is faced. With an ICT expert available to respond to any kinds of troubleshooting, the branch managers are also able to contact them for potential solutions. Furthermore, it is also the responsibility of the branch manager to collect and report all the problems that are encountered by the CHWs to the ICT technicians; it is then their responsibility to solve it. This chain of events is described by one of the BRAC developers:

> "When they [CHWs] face a problem - they will let the program organizer or the branch manager know. So the branch manager, he will collect all sorts of the problem. He will try to identify what the problem is and he will give a report on the problem to authority"

Although the PO is still the primary contact for CHWs for assistance in regards to medical and technical assistance, the CHWs are also aware that they can rely on other levels of authority depending on the severity of the problem. The ability to have this chain of authority in place

within the m-health service delivery strengthens the CHWs overall practice, as it ensures that they have the appropriate support and guidance in times of need.

Description of the call center

In addition to the program that assists with the m-health service delivery, there is also another form of support provided by the call center. The call center helps to bind the m-health system together. With the data maintained and stored at this location, the call center agents have easy access to the names and contact numbers of individuals within the community. With their 24-hour service, the patients are able to contact the call center agents whenever there is a problem. Having the ability to identify specific patients, it is then the responsibility of the call center to ensure that proper arrangements and referrals are made for patients. This subsequent section will describe the call center functions by initially discussing the primary use of the call center, followed by the call center's referral responsibilities.

Primary use of the call center

The overall intent of introducing a call center is for patients to have an emergency contact number when they have health complications. When mothers are unable to reach the CHWs, they have to option to call the call center where they can receive assistance. As described by a BRAC developer:

> "With the call center they are getting the direct solution. They are gaining from this, as they get step-by-step direction"

In addition to the step-by-step guidance, the call center has on-site paramedics who also respond to community needs. These medical professionals within the call center are able to provide potential solutions for any problems. When patients are categorized as high risk, specifically mothers in their last trimester, they are encouraged and educated about the importance of calling

the call center during times of emergency. Furthermore, if the mothers have any concerns regarding their own health or their child's health, they can expect to receive appropriate advice from the call center agents. It is the responsibility of the call center agents to make sure that the patients' requests are met. As described by a CHW, the following occurs when a call center responds to call:

> "First they will talk to the patient, see what they want. Does the patient want to talk to me? Does she have a problem that she needs to go to the hospital? Does she need transportation arrangements?'

These questions are frequently asked to all the patients calling in, to ensure that the patients have all the applicable details regarding the patient's situation. Additionally other staff members, such as the CHWs or the SSs can call the call center for assistance themselves. This is described by one of the BRAC developers:

> "Sometimes you can see that our SSs, and our SKs don't know, for example at night. This is when they themselves call the call center and explain their circumstance - since they have the call center number as well."

As described, the call center acts as a focal point where staff and patients can call for information and advice. Along with the responsibility of providing immediate assistance, the call center's other main objective is connecting the patient to the appropriate contact, or to their requested contact. This is further discussed in the following section.

Referring patients

Along with immediate assistance, another important component is the ability for the call center to refer patients. By referring patients, the call center is connecting them to their desired contact. As per request, the women could wish to speak to their CHW, their SS, their husband, their mother, their doctor and so forth. As described by a BRAC developer:

> "When they call the call center during the problem, and they ask to speak to an SK, or a SS, that they need them, in that case the call center will connect them thru to the SS or SK - whoever they want to speak to - if it's a PO or an SK, whoever it is they will connect you through."

Apart from asking about the problem, it is also the responsibility of the call center to ask the patients whom they would like to speak to; this is suggested by the BRAC developer:

> "Depending on the problem, I mean they will ask who do you want to talk to - our health worker? Should I connect you with our health worker nearby? Or a medical officer? And depending on the mother's severity, they will call."

By understanding that the call center is a referral point, all staff members involved with the m-health service have to be prepared to receive phone calls from the call center. Once the call center has contacted the appropriate contact, the call will be transferred to them, as well as the overall responsibility of the patient. As described by a CHW:

> "If she needs to talk to me then they connect her with me. They tell me to talk to this patient and find out what's the problem. This is what the call center arranges"

Furthermore, people of higher authority, such as POs and medical officers are also aware that high-risk complications will be called in, and during this time their immediate assistance will be necessary. As exemplified by one of the BRAC developers:

> "A patient that calls in to the call center saying their water broke then they immediately connect it to me, they say speak to the doctor. They [call center agents] say there's a patient in Kunipara, they find my number and connect me, saying sister give us a solution. It is such that right away the patient can speak to me – they say doctor I have this problem, my water broke what do I do now?"

Understanding the urgency of the problem, it is the call center's duty to refer the patient to the right person. This is important especially when the patient is unable to get in touch with the CHWs or SS directly; it is therefore the call center that can provide the immediate assistance. Additionally, when complicated cases require hospital attention, the call center can directly

contact the staff at the hospital, most often the POs, to make the appropriate arrangements. As explained by a BRAC developer:

> "If they see that they cannot solve the problem, they will tell them to go to the appropriate place - like go to the Dhaka Medical (hospital) and we will inform them from here. At Dhaka Medical we have our POs, who are informed about who's coming and what needs to be done."

In order to be accurately referred, the patient only has to rely on this one contact number – the call center number. This one-stop-center therefore simplifies the overall contact procedure for the patient. Through this phone call the patient can expect that all preparations will be made to address the problem at hand, including extreme cases that require arrangements for hospital admission. With the large number of responsibilities, the call center overall plays an important component within the m-health service delivery. Not only do they maintain all the data collected, but also they are responsible in guiding the patients through problems and ensuring that all their needs and requests are addressed.

Summary of the M-health Service

Overall, it is evident that the m-health service incorporates multiple facets that include a variety of components. Although the smartphone application is central to this research study, it is only one of the components within a complex system. By interviewing the three different sources: the BRAC developers, the CHWs and the villagers, it demonstrates each of their knowledge levels on the m-health service. Additionally, a comprehensive understanding of all the existing features was gained ultimately providing a full picture of the m-health service.

Common themes among participant groups

Within this section of the paper, the common themes will be discussed, specifically bringing attention to the themes that are shared among all three participant groups. By using this

method of triangulation from different sources, it will therefore validate the suggested themes. The four major themes include (a) strengths and benefits, (b) knowledge of the service, (c) challenges and barriers and finally (d) areas of improvement. These themes, as well as the sub-themes provide a collective understanding of the how the service is perceived, how well it is understood, and where further efforts need to be made.

Strengths and Benefits

The ultimate objective of the MNCH initiative provided under Manoshi, is to improve the lives of mothers and children in the urban slums of Dhaka. As a result, the m-health service that has been developed and advanced to benefit the villagers within the community has generated two different types of benefits: technical benefits and consequential benefits. The technical benefits are associated directly with the service; these include the ease of communication, faster response times, simplification of tasks, enhanced access to medical history, categorization of severity, increased accuracy and lastly increased savings. The consequential benefits are the broader subsequent advantages that are due to the existence of the program. The ones discussed in this section include the novelty of the service, the trust in the program, the empowerment of the CHWs, and finally the improved health care system.

Technical Benefits

When discussing the technical benefits, the main purpose of the study is to use the participants' perceptions to highlight the strengths of the program services. Since all the topics discussed in this section are directly related to the advantages of the m-health service's technical features, they are termed as technical benefits.

Ease of communication:

One of the main strengths of the m-health service is the ability to provide immediate assistance for mothers in need. As described by one of the BRAC developers:

> "From what I see the primary benefits are that everything is instantly happening - right away a mother can find out anything."

This instant ability to find information therefore requires simplified modes of communication. As demonstrated a common consensus exists among individuals in each participant group, that the process of communication between the community and CHWs has become more streamlined. All three sources highlight how the access to a mobile phone has made it easier for community members to get a hold of the CHWs anytime and anywhere. The community is provided with cards or stickers that contain the CHWs contact numbers. By calling the CHWs, it is a better means of communication as opposed to what occurred before the m-health implementation. A BRAC developer in the following excerpt describes this:

> "There is a lot more convenience with this service. The job that we did manually referring SS or SKs - if there is any complications or problems where we would have to refer, we have to be physically there or find a way to do that. But with this service, when there are any complications or any problems there is that convenience for the people."

This mobile phone therefore eliminates the time wasted waiting for the CHWs, as immediate contact occurs through the mobile phone. In addition to having this convenience, there is an added benefit of having the CHWs available to the community at all times. As stated by a BRAC developer:

> "We tell them that our phones are open all the time - 24 hours, so whenever there is a problem they can call right away."

Five out of the seven BRAC developers comment on CHW accessibility, suggesting how this mode of communication has allowed the CHWs to become easily accessible to the community. Additionally the CHWs highlight their availability, by stating:

> "However late it is, if they call they will find us."

Although only two out of the seven CHWs mention this ease in communication via the mobile phone with the implementation of the m-health service, the CHWs are aware that the much of their responsibilities will be transferred onto the mobile phone. In reference to the perspective of the villagers, there is also a majority of them (six out of seven) who agree with this finding. As described by one of the villagers:

> "It is good, because let's say they went somewhere to visit some other patient and I can't find them or they have gone somewhere far, and with my problem I can't find them, I would have to wait for them but with the mobile I can call and speak to them about it. Wherever they are I can speak to them."

This confirms the fact that the m-health service has improved the ability to communicate with the CHWs about the women's problems.

In comparison to the process of communication with the CHWs, the process of communication with the call center includes a limited number of instances within the findings. It does however have data triangulation among the sources. With three BRAC developers, one CHW and two villagers commenting on this subject, there is a general agreement that the call center is also able to provide immediate assistance. As described by a BRAC developer:

> "If for some reason due to electricity my mobile phone is off, and that mother tries to call me, she won't find me but the call center is always open and there will never be an issue with electricity there. All the information and set up is established over there. So this is one of the biggest reliefs - that even if they don't find us, they can find people at the call center right away. With this m-health initiative, this is one major convenience that we have as the call center can also see their data right way."

Although the CHW is the primary contact during problems, the villagers are also aware that the call center is available at anytime if the CHW cannot be reached. This is explained by one of the villagers:

> "When I can't get a hold of the SKs I call them to ask them about my problem."

Although the call center is an important contact, it can be seen that the ease of communication has higher value when contacting the CHWs, as opposed to the call center. However it can be reiterated that overall the process of communication between the villagers and the CHWs, and the villagers and the call center, has been simplified with the implementation of the m-health service. With the CHWs being accessible from any location at any time, they are the primary mode of contact. However when they cannot be reached, the villagers' communications are supplemented with easy access to the call center, which acts as the secondary mode of contact for the community. This therefore is a major strength, as it creates ease in communication for the villagers, enabling them to have immediate assistance at all times.

Faster Response Times:

Along with the ease of communication, another strength associated with this service is the speed in which problems are addressed. A BRAC developer describes this objective in the excerpt below:

> "Our main objective is to…well the first one is to speed up our services and to reduce the delays in reaching services to the community."

With faster response times, the community can expect that they will have provided with immediate solutions and steps of action when faced with a problem. This is observed within the findings, with common agreement among the three sources. From the data, two BRAC

developers, three CHWs and three villagers comment on the immediate responses provided. As mentioned initially by a BRAC developer:

> "First of all we want to reduce the delay so there is no way that it is comparable with going physically and helping them or directly, electronically connected and helping them - everybody knows that it is less time consuming."

This highlights that the in comparison to what existed previously the m-health service is less time consuming in providing assistance. The CHWs are aware that when a call is made they are responsible for providing appropriate advice. This is described by one of the CHWs below:

> "Most the problems come from pregnant mothers, like they are vomiting and they call here. They ask what do I do? I usually give them advice, and if it happens alot, then I refer them to the hospital - this all happens over the phone"

This is confirmed by one of the villagers:

> "If we have any problems or concerns we can ask about it and they can let us know what to do. If there is any illness they can tell us what to do – that's why we call them, to know."

Having the ability to provide the appropriate guidance over the phone is a key feature with this service, as villagers no longer have to wait for household visits, or the physical need to attend a clinic, as they can expect instantaneous advice through the phone.

In addition to the fast response over the phone, the smartphone application is able to provide instant feedback. When CHWs collect data on the smartphone application, the data collected are sent to the BRAC managers in charge, where they are screened and analyzed for high-risk cases. Two BRAC developers, three CHWs, and finally one villager observed this finding. As described by one of the BRAC developers:

> "With this technology we will take pictures of you and ask questions about you. And if there are any problems then your information is sent to the doctors. They will then get in touch with you, call you letting you know if you have this or that problem and if you need to go here or need to do this."

In comparison to what existed previously, the information collected through paper-based registries would be received months after collection, therefore delaying the ability to screen the population for high-risk problems. As described by another BRAC developer:

> "The register that we have, I only get the data after one month, such as the total population, how many people are pregnant, who just gave birth, who's sick, how many newborns are there, if there are any children under the age of five. The total population I get after one month - from all the visits. But with the replacement to mobile health, if I can see what work they have done, that work that I can see today."

Having the ability to have this instant awareness of population health is advantageous as problems are addressed rapidly. When CHWs were asked about the benefits of this service, similar responses were found. As described by one of the CHWs:

> "Well with the pregnant females - there is everything in here that we record about them - whatever problems they have we can put it in the phone. Like if she has water in hands and feet, if she's had any bleeding problems – that's all in there. So all this information is being sent, so then the doctors can talk to them about those things. Because they have access to that information to solve the problem – that's why it's good."

Although only one villager mentioned this, there is awareness that this phone application collects individual information that can be addressed by doctors if necessary. The villager reinstates this below:

> "The sisters have told us that with this, there will not be any problems. And if there are problems we can tell them about the problems, we can tell the doctor about the problem and they can understand the problem with the mobile information. That's why with the mobile phone there is then no problem or difficulty."

Overall therefore, there is a general understanding and validation among the three sources that the m-health service provides immediate responses to any problem, these can be over the phone concerns, or problems that arise through the data collected on the smartphone application.

By having this reassurance of instant feedback agreed upon by all sources, it qualifies as being a benefit in the program.

Simplification of Tasks:

Along with the benefits experienced by the villagers, there are also benefits experienced by the CHWs. By having the m-health service implemented within this community, the CHWs can expect that their smartphone can provide better assistance. As described by one of the BRAC developers:

> "I told the SKs that the phone would be good. At first the SKs were a little scared about how they were going to use the phone but I told them there are no problems with this - that this is a good thing that you can easily work with."

With the implementation of the smartphone application, one common finding among all three participants is that the CHWs will no longer have the inconvenience of the registries, but instead will only need to rely on the mobile phone when they are working in the field. Two BRAC developers, two CHWs and one villager mention this finding. As described by one of the BRAC developers:

> "If we can do all this work within our mobile, the first thing that will be done is that we won't have to carry these heavy, heavy, bags anymore. I won't have to write in these big registries and for every month I won't have to write all these reports."

The inconvenience of the registries includes the overall physical weight, the lack of organization and its ability to get lost or damaged. This is described in detail by one of the CHWs:

> "With paper things can get lost, it can get burnt, water can wash it out or with writing there are mistakes and cross outs and I myself can't understand it. But for these things, these are recorded, if I do an option wrong I can go back, if Rashika's mom has a BP (blood pressure) of 122 but I wrote 130, I can go back and fix it, but with the register there are cross outs. So that's why this is better."

From the perspective of the villager, they too can see that the CHWs prefer the phone. As described by one of the villagers:

> "When I see them carrying the register and the phones, I think the phones are easier for them."

At present with both methods being used concurrently, there is validation from all three sources that there is a general preference for data collection on the smartphone application as opposed to the registers. This suggests that with the implementation of this m-health service, there is more convenience gained from using the mobile technology in comparison to the traditional paper based method.

In addition to the convenience of collecting data with the smartphone application, there is also the convenience that data are sent in without any delay. Although there were only a few references about this, there was still data triangulation. With one BRAC developer, one CHW, and one villager commenting on the speed of collection, it can be implied that it simplifies their responsibilities. As described by a BRAC developer:

> "We want to shift from the paper based services to non-paper based because it takes lot of time to generate reports from there. From one page paper to another, its right now one, two, three, four, five steps that they [CHWs] have to compile the reports – all manually. So if it is electronically we can generate this report, it will save us our time as well as our resources."

By having information available electronically, it allows for quicker access, as opposed to manually accessing the content from each register. This speed in which data are sent, is commented on by the CHW stating:

> "If I wrote this on paper, then I wouldn't be able to send this information right away"

Furthermore, the villager is able to recognize that in comparison to the register, the mobile phone requires less time. The villager confirms this below:

"I think the phone takes less time overall"

These findings are able to show how the responsibilities of the CHWs are simplified with the implementation of the m-health service; therefore this is an advantage for them, as they can identify the registers as being a physical burden, as well as time-consuming method of collection, in comparison to the m-health service.

Enhanced access to medical history:

The ability to access an individual's medical history is a strength that was shared among only three CHWs and one BRAC developer. Although this strength is not triangulated amongst all the sources, it can be assumed that with the infancy of the smartphone application, the end users have yet to experience this feature. As explained by the BRAC developer:

> "The great thing with the phone is that this information will stay with us year after year. If I sit here and want to look back at the problem that occurred 10 years ago, I can, because the information can be stored. But the book can easily get lost."

This ability to have access to the medical history is an important feature within the smartphone application. This will become more apparent to the villagers as the program develops, as it will contain their health profile. The inconvenience of the register is suggested by the CHW below:

> "With the mobile, the work that we collect, it's in the software, and after 2 years if I look at this software I can look at the data, but with the register if the book burns, or gets lost - then we can't see it anymore."

Additionally there is this realization from one of the CHW that the transition into digital data, helps store more information, as mentioned below:

> "Well it's good that it is digital, everything is digital, for us this is great. We can keep a lot of things in here."

There is recognition that this digital mode of collection on the smartphone application has a larger capacity, as well as greater longevity in comparison to the registers. This is a benefit of the m-

health service, as individuals within the community can expect that their medical profiles will be well managed, and that the CHWs and their superiors can have access to them in the future.

Categorization of severity:

Another benefit of the service, specifically with the smartphone application, is the ability to categorize individuals based on their health severity, identifying which individuals are high-risk. With only two BRAC developers discussing this feature, it suggests that only people with higher levels of authority are aware of this advantage. As described by the BRAC developer:

> "If there is a classification system of the complaints, we can categorize them and we can handle them separately. Like for minor complications they will handle it by the paramedics, the moderate will be doctors or consultants and the severe ones will be referred to the facilities."

This is further expanded on by another BRAC developer:

> "If there are any high risks out of those mothers, they will not have to say. The SKs will not have to say that they are high-risk mothers, because the data will tell them how many high-risk mothers there are in this area. The indicators that we have [are] fixed, from there we are getting the data for the high-risks. There are nine to eleven sign symptoms, if they have this that means it is high-risk. We can separate the high-risk mothers, the normal mothers, we can separate them all. The high-risk, where she can go to get the best treatment, we can also inform them."

This supports both the patients and the CHWs as they can recognize a high-risk patient and address their needs accordingly, which can be viewed as an overall benefit of the program.

Increased Accuracy:

Along with the ability to identify the risk level of the patient, the service is also able to ensure accuracy in the data collected. Although two BRAC developers mentioned this, it can be assumed once again that with the infancy of the program, the CHWs and the villagers have yet to receive feedback regarding accuracy levels. By creating this smartphone application to collect data, there is an expectation that it will create a more accurate representation of the community.

As described by one of the BRAC developers the previous method of collection contained numerous errors, reducing the validity of the data. When describing the benefits of the electronic format, the BRAC developer comments on paper based data collection:

> "Few months back our monitoring unit did a data validation check in [the] case of one indicator - they found that 40% of the data was not accurate, over reporting. So this kind of inaccuracy will be reduced"

With such a high number of errors within the paper-based method, it is assumed that the smartphone application will provide more accurate information regarding community health. This is a view is that is shared by another BRAC developer:

> "Secondly the data collecting is more accurate, no fake or false data are there."

The increasing the credibility of the data collected on the smartphone application.

Increased savings:

The final intentional benefit of the overall m-health service is the ability to reduce costs for the villagers. This was only mentioned by one CHW. With the existence of the program, the CHWs provide a free service to the community, by collecting information on expecting and new mothers and providing them with instant communication and advice. In addition to this, the villagers are able to gain further, as the CHWs can refer the patients to hospitals or doctors at reduced costs. This is further explained by a CHW:

> "Because this doesn't cost and money. For the delivery at the clinic it only cost little money, so with little cost they are getting a proper delivery that's sanitized. Whereas if they did it in the hospital the bill would be a lot higher - it would cost more. If it's a normal delivery then it's very easy for her. Now if for we have to give a referral for her, where there is a little more high risk - like the mother needs to get a cesarean - with this [referral] slip she can get it done for 6100 taka here, whereas they would be paying more if they went somewhere else - 15000 to 20000 taka, so when they see this, they know that the reason that we come is for their own good."

Apart from relying on the service for instant communication, advice and guidance, the community can potentially rely on the service for increased savings.

Consequential Benefits

This section describes the benefits that are experienced as result of the program existence. The participants' perspectives strengths coincide with the overall value of the program, allowing for a wider impact on the community. These include: the novelty of the program, the trust in the program, the empowerment of the CHWs, and finally the improved health care system.

Novelty of the service:

As discovered within the findings a novelty is attached to this service. Although limited references were made regarding this idea, data triangulation supports it amongst all three sources (one BRAC developer, one CHW and one villager). With the addition of these new smartphones within an urban slum, there is an interest attached to this new technology. This is exemplified when a BRAC developer was asked if the CHWs had any trouble learning about the smartphone service:

> "They find it interesting, they have been provided [with] a smart phone, so they are happy."

It is due to the novelty of having ownership of this smartphone that the CHWs are further intrigued to learn. Furthermore, when a CHW was asked if the villagers liked the service, and if there was a demand for it, they replied:

> "Yeah everyone says that: sister this is much better, we get to take our picture and everything is in the mobile, all the work is done here. So they are happy"

The ability for this smartphone application to capture all their health information as well as their pictures is a new concept for the villagers. It is therefore the use of such a device that makes them happy. The receiving end confirms this, when one of the villager states:

> "I like this this thing is new, it looks nice, it sounds nice, I like having the pictures taken."

It can be suggested with this statement that the novelty takes preference over the actual purpose of the smartphone device. This therefore highlights the fact that implementing these smartphone devices, although intended for MNCH data collection, are also appreciated purely due to the novelty attached to it.

Trust in program:

In addition to the novelty of the service, another strength is the trust the community has in the program. By having this wider impact of trust, the community can depend on the program to improve their overall well-being. As mentioned by one BRAC developer, one CHW and two villagers, there is a common agreement that the community is able to recognize the efforts that are being made for them. As explained by a BRAC developer:

> "At first the mothers, when we used to take the pictures and collect the data, they didn't agree to it, but now when they see the work that we have done with them, and are still doing, all the data that we are getting - they then realized that here, the data that they are collecting is benefiting them."

Although at first there was resistance, ultimately the community has come to appreciate the care that is being provided. This is once again exemplified by a CHW:

> "They think that the work that we do is good - they know that our goal is to make sure the mothers are doing well - so we explain to the mother first what we are doing - a lot of the mothers before - for example we've been doing this for seven years, before a lot of mothers wouldn't let us in, now it's come to the point where

> they realized no BRAC, that have come here for us before and now, they've come for our own good"

Correspondingly the villagers show their appreciation for the service provided. They are aware that when the CHWs come to visit them with their smartphone devices, they are providing them with a service that is ultimately benefiting their overall health. When a villager was asked why she would want this type of m-health service in her community, she responded:

> "For my well being, so that I don't have any illnesses or problems."

Furthermore, she continues to express this trust in the program when she states:

> "They do this so that for myself and for my kids there have no problems, they do as much as they can to make sure there are no problems."

This therefore exemplifies the overall gratitude that the community has for this service, understanding that they are providing this smartphone service for the betterment of themselves, as well as their children. By having this trust in the service, it acts as an overall advantage for the m-health program.

Empowerment:

The trust created in this program is primarily due to CHWs, as they are the primary providers of the m-health service. With limited jobs offered to women within the country, the opportunity to be a CHW comes with many responsibilities that create a sense of empowerment. Being the front line workers, it is their responsibility to ensure the health of the community, empowering them as individuals. As described by one BRAC developers, three CHWs and one villager, there is a mutual understanding that the CHWs' roles are significant within the community. As described by the BRAC developer:

> "As they have a smart phone and a cell number, we thought that the CHWs become more empowered in the community. Earlier when we provided them with the stethoscope and the pressure machine, the communities thought that, yes, they are a little doctor who can provide us with services. So these things empower the CHWs more and the communities recognize them as well. So these things we think, CHWs are, they can - how do you say - it can increase their status in the community - acceptance will increase."

As suggested by this excerpt, by having the role of a CHW, it enables them to feel respected and known within the community. This is reinforced by the CHWs as they can recognize their authority when they are on the field. As mentioned by one of the CHWs:

> "Now that in this area everyone knows who I am they ask me whenever they see me."

This ability to acknowledge their worth as a health care provider empowers them, as they know that the community can rely on them for answers. Furthermore they are aware that this role as a CHW increases their opportunity to learn as well as interact with the community. This is exemplified by two CHWs in the following:

> "I have the opportunity to learn a lot."

And,

> "Well I see more people now, I'm talking to people. Before I was alone at home, and now in Manoshi I meet so many people and talk to them a lot more."

The CHWs act the primary point of contact the community, providing villagers with solutions. This is suggested by one of the villagers when she states:

> "People ask about it all the time and I tell them these sisters come and take care of us."

By having the villager identify this CHW responsibility, it empowers the CHWs, as they are aware of their influential role within the community. Having the ability to conduct their daily tasks, with the assistance of the smartphones, gives the CHWs a higher sense of responsibility; it

is therefore a result of the m-health service that they have been able to enhance their sense of empowerment.

Additionally, as observed by one BRAC developer, the community is also empowered by this service, as they have access to health at their fingertips. This is exemplified in the passage below:

> "It also empowers them, they can take their own decision. They can call, they can ask for their help"

Having the convenience of using mobile technology, allows the community to take responsibility for their own health. This ultimately benefits them, as they can feel more empowered as individuals.

Improved healthcare system:

With the implementation of the m-health service, the community is able to access remote healthcare assistance, thereby receiving immediate feedback and solutions. Assessing the broader impact of this service, it is apparent that it is assisting the healthcare system due to the fact that many of the problems are solved over the phone as opposed to relying on physical medical attendance. Within the findings only two BRAC developers commented on this. As mentioned by one of the BRAC developers:

> "We are directly referring the patient to the medical college hospital, tertiary level, so we should not do that, we have refer first to primary, secondary then tertiary. But as we know in primary and secondary there is no service, that's why we are referring to tertiary level. But with call center we will provide some primary and secondary service within our system. Like with paramedics, with doctors, and then we can refer to the higher levels - it will also be good for the health system."

With minimal access to primary and secondary levels of care, this service is able to partially fill this void by addressing problems sooner through the call center. Another BRAC developer further supports this when they state:

> "Before whatever the problem was, we would tell them to go right away to the hospital. Now with the help of the medical assistant, their problem is solved to the best of their abilities. They do whatever they can to help them with the pain - when they can't figure it out then they send them to the hospital. So ultimately the referral system has become less complicated."

The m-health system therefore is supporting the healthcare system, as the system provides a limited amount of primary and secondary care, reducing the burden on tertiary care. Ultimately, the implementation of this m-health service has the potential to impact the healthcare system.

Apart from reducing the burden on the tertiary levels of care, the m-health service also provides the opportunity for increased health knowledge sharing. One BRAC developer mentioned this, suggesting that through the use of the smartphone application, the increased speed of data collection allows the villagers to communicate more with the CHWs about other concerns. As described by the BRAC developer:

> "We found that it is a good medium for communication as well, because the data collection process - the time is getting reduced so that the communication between the CHWs and the households is increasing - so there is big time for knowledge sharing."

Having more time to communicate and ask questions about health enables the community to learn more about their own well-being. With this additional time, the villagers were able to gain essential advice about health, nutrition or any other matters that are of concern to them. The same BRAC developer further describes this below:

> "From the villager side it is pretty much helpful for them because they can share their problems with the community health workers. They get more time from the community health workers, but earlier they were dealing more with the data collection and writing you know. But nowadays they can talk, and advise much more, and the communities they can learn more from the community health workers as they get more time."

By learning more about their health, the community is benefiting from more health knowledge sharing. This therefore can contribute to the overall healthcare system, as the villagers no longer have to rely on higher levels of care to provide advice or assistance.

Summary of the Strengths and Benefits

It is apparent from this section that there are multiple strengths of this m-health service. By looking specifically at the technical benefits, there is an overall appreciation of the m-health service's accessibility. By having a strong appreciation for the ease of communication, faster response times and simplification of CHW's responsibilities, the m-health service is able to provide a greater level of convenience to all three sources. Furthermore, it is the ability for the m-health service to relay these technical strengths into broader advantages that makes the service more valuable. By empowering the CHWs and creating a sense of trust for the program, the community can depend on them for answers.

Knowledge of the Service

This section focuses on the theme: knowledge of the service. With this new initiative in place, there is an obligation for BRAC to inform the community about the existence of the m-health initiative and the different services it has to offer. The first part of this section will focus on the methods of educating the community; this includes how BRAC inform the community about the contact methods, and how they inform the community about the use of the smartphone application. This is then followed by a section, which describes the external interests in the program.

Methods of educating the community

It is apparent that the CHWs are the main mediums through which the community is educated about the m-health service. Being the primary point of contact for the community, they are responsible for informing the community on all current activities. To understand how they inform the community about m-health features, the following will be discussed: educating the community about primary contact methods and educating the community about the smartphone data collection.

Educating the community about primary contact methods:

As defined in the m-health service description section, one of the responsibilities of the CHWs is to inform the community on the contact methods. This involves providing them with a sticker or a card that has all the numbers of the primary contacts. As described by six of the BRAC developers, it is common knowledge that these informative materials are provided to the community. As expressed by one of the BRAC developers:

> "The card that we provide - that has all of our phone numbers listed - also has a call center number that they can call and get instant contact."

Understanding that it is their responsibility to inform the community, the CHWs ensure that during every household visit they provide the contact information to them. This was addressed by six of the CHWs, where one states:

> "If there is a problem, we have a card that we give them that has our mobile number, so we tell them if they have any problem, any problem at all, give us a call on that number"

As demonstrated in the aforementioned passages, apart from providing the contact numbers to the villagers, it is also the CHWs' responsibility to let the villagers know when they can call. Making sure that they are aware that whenever a problem arises, calling one of the primary contacts is the

first step of action to receive immediate assistance. Although three villagers confirmed that they had received the informative material, one villager was able to describe when the contact numbers should be used:

> "We were told that if there were any major problems that we should call this number that is in our books."

All three sources confirm the fact that the CHWs not only provide them with contact numbers, but also educate them on when to use them. This consequently enables the villagers to learn about the m-health service and its primary functions.

Educating the community about the smartphone data collection method:

In addition to educating the community about the use of the primary contact numbers, the CHWs are also responsible in educating the community about the smartphone data collection method. With the villagers accustomed to the traditional paper-based method, they are now exposed to a new collection technique that is carried out on a smartphone application. The CHWs therefore have to introduce this smartphone to the community explaining its overall functions. This is explained by six of the BRAC developers, whereby commenting on the fact that the CHWs are the main informants of the new service. As stated by one of the BRAC developers:

> "With this they tell mothers in the first month, that there is a new technology in place. With this technology we will take pictures of you and ask questions about you. And if there are any problems then your information is sent to the doctors. They will then get in touch with you, call you letting you know if you have this or that problem and if you need to go here or need to do this. By doing this we got the whole community involved and aware that we are using this service"

By letting mothers know the details of the smartphone application, the community is educated about this new service. This is reiterated by five of the CHWs, where they describe how they inform the community about the new technology. As described by one CHW below:

> "Now we tell them there's a new program called m-health - meaning mobile - and that everything that we collect, we keep it in there and it will be collected everyday. Not like we did before, then we send all this information. So if mothers ask about it - they know that this is the new way we are collecting information."

Although only mentioned by two of the villagers, they are aware that the CHWs are now using a new method to collect data. As commented by one of them:

> "When they are taking the pictures and collecting information they tell us now we will use our phones not the register."

There is therefore a common consensus that the CHWs are the educators of the service, they are the vehicles that provide the knowledge of the m-health service to the community, ensuring that the villagers are aware of exactly what the CHWs are doing.

External interest

Another component within the knowledge of the service theme is the external interest that surrounds the m-health service. As previously mentioned, it is common for the villagers, specifically the CHWs' clients, to ask about the service, however there are others outside of their clientele who are curious to learn more about this smartphone application. One BRAC developer, three CHWs and four villagers mentioned this finding. As mentioned by one BRAC developer:

> "When the SKs go out to work, a lot of people ask about it - what is this? What does it do? They then tell them that before when we wrote and collected information in our books, now alongside this, we will collect data on our phone."

This therefore suggests that people take interest in the program, wanting to know more about what the services has to offer. In addition to the curiosity within the people in the community, there is also curiosity among other CHWs who do not have the smartphone privileges. They ask the CHWs who use the smartphones, about the service and its overall functions. As described by one of the CHWs interviewed:

> "In the training center there are a lot of new ones - we've been around for three years so we definitely teach them a lot about it - we showed them, we taught them - and they like it"

The smartphone application therefore attracts attention from multiple sources of people. Even within the community level, other people approach the villagers about the m-health service asking them questions about it. As described by one of the villagers:

> "They all want to learn about what the SKs have told us, the advice that they give us. They ask to know everything."

With this novelty of the service, there is a growing interest among people to find out more about it. Although it has been only implemented in the last three months, the findings capture the m-health service's popularity and the community's curiosity to have access to this knowledge.

Summary of the Knowledge of Service

As described, an important component of the m-health service is the method by which the community is informed about its existence. Understanding that it is the role of the CHWs to educate their clients as well as the external interests about the service, it consequently makes them the primary mentors of the m-health service. Although it is assumed that the CHW's clients will be exposed to the m-health innovation, it is the interest from other members in the community that captures the *diffusion of innovation*; the social processes involved in communicating a new idea (Rogers, 2002). With only three months into the smartphone application, this triangulation of data is able to highlight the community's curiosity for the program, suggesting how quickly the information transpires through the community.

Challenges and Barriers

Any new innovation has challenges and barriers for those involved with the service. Capturing these challenges allows for further improvements and developments. As described in

the participants' perspectives a wide array of problems exist. Within this section the themes that are described include the following network problems, modes of collection, costs involved, migration and finally the inconsistency of health problems. As suggested in the next section, many of these challenges can be targeted as potential areas of improvement.

Network Problems

Out the challenges faced with the m-health initiative, the most commonly mentioned challenge was the network problem. With three BRAC developers, six CHWs and one villager commenting on this issue, there is an overall understanding that this is the m-health service's most prominent barrier. As stated by one of the BRAC developers:

> "Sometimes it's a network problem or there's something wrong with the phone. So far there hasn't been many problems, only the network problem."

This innovation is capable of providing real-time data, and remote assistance, it still relies on the ability to connect to the network. With the reliance on the network, it can sometimes hinder the responsibilities of the CHWs. This is described by the CHW in the excerpt below:

> "There are network problems – that's the main thing. Even with our normal mobile there is network problem. In the area that we work there's that problem all the time - and even saving it becomes a problem."

This suggests that when CHWs are collecting data on their smartphone applications, the ability to save data can often be affected by the network. If the network is poor, when CHWs collect data on the field, they have to save the data until appropriate network is available. Additionally on the receiving end, the villagers also suffer from poor network reliability, which reduces the ability to get in contact with the CHWs. As described by the villager:

> "Sometimes the problem with the phone is that you can't get network then later once I am home I can contact them."

The villagers therefore have to find an appropriate location, in this case, their own home, to get access to the network. Once they have this access they can make appropriate calls. With 115.627 million active mobile subscribers (BTRC, 2014) within the country, representing 74.7% of the population, the inconsistency of the network is beyond the means of the m-health service developers. Recognizing that this is a nationwide problem, the developers have altered the smartphone application to address the problem. The BRAC developer explains this below:

> "When we work in the slum, sometimes there is no network - I can't send the data. This was a problem before but not anymore. Now we can save the data, and once I get to an area with network I can send in the data. This used to be a problem but not anymore."

By understanding the problems created with limited or no access to the network, the developers have recreated a store and foreword software so that the CHWs can collect and save the data on their smartphones, so that once they are in an area where there is network, they can send the information through. Although this has mitigated the network problem, the ability to find a working network access point is an added burden for the CHW. After the CHWs have collected the data, they have to actively find an appropriate location with network access to physically send in this information. This is described by the CHW below:

> "The only thing with this one is that in an area where there is no network - when we record our data - we have to send it in, but after that, in an area where there is no network, we have to go a little further to look if the area has network - when we find it then we can send it through. If there is network we send it, but if there is no network anywhere, then after 2pm when we come back to the office, if there is network here then we send it."

This lack of network access therefore is an added responsibility for the CHWs. Although this is the biggest challenge faced with the m-health service, it is still however a problem that needs to be addressed nationwide as opposed to being addressed by the service itself.

Modes of Collection

The CHWs traditionally used a paper-based method, that included physically writing data into their registers. With the implementation of the smartphone, the overall intent was to replace these registers with a data collection application on a smartphone device. Although this is the main objective, during this transition from register to smartphone, the CHWs are responsible for collecting data in both formats. Within this section, the problems experienced from the modes of collection will be described, starting with the challenges faced by the individual modes of collection: paper-based and smartphone based, followed by the problems experienced by the dual modes of collection.

Paper-based collection:

Prior to the introduction of the smartphone application, the CHWs have been using their registers to collect data. This has increased the CHWs' workload as there are two modes of collection: the smartphone application and the paper-based register. However it is important to identify the challenges experienced with just the paper-based method first. With comments from four BRAC developers, three CHWs and one villager there is common agreement on its inconvenience. As indicated by one of the BRAC developers:

> "When they are using the paper based system, so they need much more time to write, to calculate everything."

Additionally, the BRAC developers describes that by using the paper-based method, it consequently delays the ability to evaluate the data collected. A BRAC developer elaborates on this in the following passage:

> "So we want to shift from the paper based services to non-paper based because it takes lot of time to generate reports from there. From one page paper to another,

> its right now one, two, three, four, five steps that they have to compile the reports – all manually"

Apart from the delays caused by the paper-based method, there is also the fear that the registers could get damaged or lost, therefore losing the vital information all collected in the field. As described by one of the CHWs:

> "With paper, things can get lost, it can get burnt, water can wash it out or with writing there are mistakes and cross outs and I myself can't understand"

There is an overall recognition therefore that this method of collection causes difficulty with problems experienced during collection, during assessment, and finally its overall maintenance. In addition to this, the end users: the villagers, are also able to identify its inconvenience. A villager states:

> "The books that they hold are heavy - it gives them difficulty, they have to go to a house and write in it but with the phone it's a lot more convenient."

Although the overall intent is to replace this method of collection with the smartphone application, during this time of transition, the CHWs still have to use the paper-based collection method. This therefore means that the CHWs have to endure these mentioned difficulties, until there is full replacement from the paper-based method to the smartphone application method.

Smartphone based collection:

In comparison to the paper-based method of collection, the smartphone application incorporates problems faced during collection as well as problems experienced with the content collected. By initially looking at the problems faced during data collection one of the main problems is the inability for the CHWs to see what they have collected. This is described by two of the BRAC developers. As stated by one:

> "They were used to [it] with the papers - and in the paper, they can immediately see that if they want to find any information about one beneficiary they could see in the register but now they cannot see on the mobile phone."

The CHWs have only been given the responsibility to input the data; once these are collected they are saved and sent directly to the server. If the CHWs choose to look back on these data, they will not have access to this information, which an pose as a challenge. This therefore suggests that even though they are the primary collectors, the CHWs have limited access to the content itself.

When addressing the content that is collected, a variety of different problems that exist, as described by four BRAC developers and three CHWs. With the smartphone application being designed with fixed categories and specific selections, it prevents the CHWs from inputting any additional information. This is mentioned by one of the BRAC developers below:

> "Paper based is easier for them because if there is nothing, they can write there, but with the software if you don't have the indicators or writing space then how will she reserve the information. If she wants to write something, where will she write?"

With a rigid application in place, the CHWs are restricted to the options found on the smartphone device, which can act as a challenge when the CHWs feel the need to note down extra information. This is described by one of the BRAC developers:

> "Because they have to send the questions one after the other if there is extra things they need to write, they can't put it in the phone so they have to note it down - so it gets complicated. So complete paperless is very difficult."

Having to note additional information that is not sent in through the smartphone application could cause discrepancies in the data, as some components will be saved on the smartphone, and some will be on paper. As reiterated by one of the CHWs below:

> "With the mobile the questions keep coming one after the other, and if we don't give an answer then we can't pass the question. There are a lot of options as well that are not on the service - that are missing, that we can't put into the phone. Without some of the information I can't move forward."

In addition to the missing content in the application, there are some questions on the smartphone application that are not applicable to the patient. As described in the excerpt above, without answering these questions, the CHW is unable to move forward. This is alluded to by one of the BRAC developers, as they elaborate on some of the complaints they received by the CHWs:

> "There are other problems, like for this mother, this question is not necessary but it has been added or this question is not there for me to ask them. The software is made in such a way that these questions are not essential for her. That's the way data has been inputted, where some of these questions are not needed - this is the type of feedback we would get from all of them."

With the development of the smartphone application, there is an overall intent for it to be all-inclusive, whereby collecting all the vital indicators needed for MNCH. Including all indicators however is a challenge in itself. This is further elaborated by one of the BRAC developers:

> "With the MNCH program we have already 400 indicators, that means we are collecting 400 data everyday for a single household. And these 400, if you want to incorporate into a single software, it is much tough for the IT person to create a software that can calculate these things."

In addition to the lack of content, another feature that is missing within the smartphone application is the ability to schedule household visits. With the development of the smartphone, people expectated that this feature would be integrated within the application. Although only mentioned by two BRAC developers, they were able to highlight the fact that the CHWs still have to rely on the registers to tell them which houses they have to visit. The BRAC developer further expands on this below:

> "Another problem is scheduling. You know in our field there is ANC and PNC, so this scheduling is maintained by the CHW by watching the register - but you don't have a functional software that can tell you that - yes today we have an ANC visit. So if the software can't give the information rightly or quickly you will miss the ANC visit."

Having this feature missing within the smartphone application therefore prevents the CHW from being completely paperless. They still have to rely on their registers to find out where and when they are going to specific households.

With the development of this application, as described in this section, some of the problems surround the lack of content, lack of access and lack of features. In order to address these challenges the software developers have to reconstruct and redesign the smartphone application to better suit the needs of the users, whereby incorporating the appropriate content, as and CHW access.

Dual modes of collection:

With the implementation of the smartphone, the CHWs are currently experiencing a transition phase where they have the responsibility to collect data on both the smartphone application and the traditional paper-based register. This therefore is an added burden for the CHWs. From the participants' perspectives having these dual modes of collection acts as a challenge for the CHWs, as their workload has now increased. Two BRAC developers address this challenge, whereby one of them states:

> "For them to work with the books and the phones, gets difficult - using both methods is harder for them."

With the CHWs experiencing this difficulty first hand, there were six CHWs who expressed this challenge, stating that the process is more complicated and time consuming for them. One of the CHW refers to this difficulty in the following statement:

> "With the register and mobile, trying to do both gets complicated. With the register we have to write it again, and we have to input it in the mobile."

In addition to the responsibility of dual modes of collection, the CHWs also have to adapt to the new smartphone application. This therefore puts more pressure on the CHWs as they are now

faced with additional obligations. Although this is a temporary adjustment, the CHWs still have to experience the challenges of using both mediums. With the intent to substitute the registers with the smartphone application, the CHWs therefore have to wait until this replacement occurs.

Overall, it is worth mentioning that within this section, there were more references made on the challenges faced with the smartphone application as opposed to the paper-based application. Although the smartphone application received a greater number, only the paper-based method received data triangulation on its challenges, with the recognition from a villager on its overall inconvenience. However, the purpose of having both methods of collection running parallel is to allow the paper-based method to act as back-up support if the new smartphone technology fails. This transition phase therefore continues until there is successful integration of the smartphone application.

Costs

With the implementation of an innovative technology, numerous costs are involved. With the novelty of a smartphone device, these costs can act as challenges for the overall program. As observed through the participants, these costs involve the initial investment, the novelty of the phone, the evolving technology, and the lack of resources. All of the costs that are mentioned are primarily individual comments made by the participants. Although there is a lack of triangulation, they contribute to the overall expenses of a smartphone initiative.

Initial investment:

Implementing an m-health initiative comes with various challenges as discussed; however alike to many program initiatives there is also the challenge of the initial costs. With this m-health initiative started by BRAC, there is a large investment involved to get the program

started. As the program progresses however, there are unexpected challenges that add to this overall cost. This therefore limits the ability to expand to a larger scale. This is expressed by one of the BRAC developers:

> "It's expensive - initial investment is high. And BRAC, although BRAC is doing, but it is still very small scale – we can't go mass scale. We are doing in small scale and we can see lots of barriers here, but when we go to scale, I don't know how we are going to handle it and whether BRAC will invest that much."

Although this initial investment acts as a challenge, by having these unexpected barriers adding to the overall cost, there is an inability to expand therefore limiting the success of the program. These unexpected challenges are further described below.

The novelty of the phone:

As mentioned previously there is a novelty attached to smartphone devices. With any new gadget, there are people who are curious to know more about it, however at the same time there is also the risk that it might get stolen or broken. This novelty therefore acts as a challenge. As described by one of the CHWs, there is a fear of owning such a device:

> "It's not challenging but to scale up a program like this - to all over the Manoshi or all over the health sectors - you need a huge training unit - so it's a big challenge actually. And as well as….right now this is the challenge I think - you have to have that scale, to scale it up. And on top of that this can fall and get damaged - so there's a risk of that too"

Although there were similar fears with the register getting lost or damaged, the smartphone device costs more to get replaced in comparison to the register. It is therefore an added responsibility for the CHWs to make sure that the smartphone is kept safely and securely to prevent any loss, theft or damage.

Evolving technology:

With any technology, updates and changes happen frequently. As described by two of the BRAC developers, the ability to keep up with this evolving technology ultimately results in a challenge, as the users have to be frequently trained about newer, more advanced models. As explained by one of the BRAC developers:

> "Technology is changing very rapidly, so today we are using smartphone, and I don't know tomorrow what we will use! And we have to again change the software and everything, and that's time consuming and not that - to get the appropriate person to help us is very difficult."

With the other BRAC developer reiterating this fact, there is recognition that with the implementation of this technology, it will require further training when updates are made, which will add to the overall costs.

Lack of Resources:

Along with the costs of successfully implementing an m-health service other resources have costs. The implementation of an innovative technology includes a need for appropriate resources that can ultimately assist in the program's development. However as mentioned by participants, many of these resources are unavailable. These include experts in the field, support from medical officers and appropriate associations with other facilities. In order to tackle this lack of resources, more investments need to be made.

The implementation of an m-health service involves the integration of health and technology. In order to do this successfully there needs to be experts within the m-health field. As described by two BRAC developers, the lack of expertise within the field prevents the program from appropriately addressing their needs. As expressed by one of the BRAC developers:

> "Even in the IT section - many people they are literally not aware about these changes and how to correlate with health, it is very scarce - this kind of expert is lacking in this country."

This inability for software developers to understand what is required for the program, is further elaborated by the BRAC developer in the following passage:

> "It's an ICT based platform, so development is pretty much difficult because we are talking about a health system, and it is not that much easy to understand by an IT professional on what we actually want.

The two different professions of health and technology trying to coexist in one initiative acts as a challenge, as they are unable to communicate with each other about the necessities of the program. This therefore delays the overall progress. To mitigate this problem, further investments need to be made, involving appropriate specialists who understand both the technology as well as the health landscape.

In addition to the lack of experts in the field, there is also a limited number of medical officers who can attend to patient problems. As indicated by a BRAC developer:

> "In our program depending on the severity of the patient, the medical officers they can go and look at the problem, if they are available. We don't have that much medical officers at BRAC so it's hard"

The lack of medical officers imposes constraints on the overall m-health service delivery. The CHWs rely on the medical officers for medical assistance; therefore with only a few available it hinders their ability to address medical concerns in the field. Additionally, the lack of medical officers imposes on CHWs own individual workloads, as now they are responsible for attending to more patients and solving more patient problems. Not having this medical manpower ultimately acts as a challenge to the overall performance of the program. Consequently in order to alleviate this problem, the program needs to once again make the appropriate investments to increase the number of medical officers hired.

Apart from the lack of human resources, there is also the challenge imposed from the limited number of sites that have implemented the m-health service. With numerous Manoshi offices throughout the country, only three offer the m-health service. This acts as a challenge

when villagers decide to relocate. As expressed by one of the BRAC developers, although they are capable of connecting patients to other Manoshi offices, they are unable connect them via the m-health system. This is conveyed in the following passage:

> "The mothers that were in Dhaka - there are other Manoshi offices elsewhere that I can link them too but I cannot link them through m-health - the reason is because they don't have m-health there."

The BRAC developers continues by stating:

> "There is no m-health link. For example, if I send them to Badha, I can have an m-health link because in Badha they have m-health services. If I send them to Romna, Kilga or Tejgao I can't link them through m-health."

By having this m-health link available to them, the transfer of patients from one location to the other is simplified. With limited locations offering this m-health service, this acts as a challenge. In order to attend to this problem, another BRAC developer mentions scaling up. They state:

> "I mean if you can't provide the service to all the beneficiaries then it's nothing"

Understanding that the m-health service is more effective when the service is expanded, the overall investment acts as a barrier. The same BRAC developer further alludes to this:

> "It's not challenging but to scale up a program like this - to all over the Manoshi or all over the health sectors - you need a huge training unit - so it's a big challenge actually."

Although the lack of m-health service centers throughout the country, the desire to expand has its own challenges as well, as numerous costs are involved.

On the contrary, to help save on costs, as mentioned by one BRAC developer, the program wants to minimize the number of POs. As described by the BRAC developer:

> "So we are hoping that if this works, well then we can reduce the number of POs, supervisory staff, so that will also minimize our costs. That is also our plan of sustainability because right now there are huge supervisory staff levels - staff in the field. Physically supervisors sometimes feel it is not possible to see all SKs together, like one PO has seven or eight SKs - so how can he monitors everyone.

> So if one shot he can sit in the desk and see their location it will be easier for them."

Since the POs are responsible for monitoring the CHWs, they find this responsibility difficult to manage, however with this m-health system in place, there can be a reduced number of POs. As described with this real-time monitoring in place, the POs can easily monitor the CHWs through the features offered from the smartphone application.

Apart from the savings proposed by reducing the number of POs, to develop such a program there needs to be the appropriate resources are needed to ensure its overall success. However as described, this adds on to the initial investment. With the BRAC developers responsible for the overall management of costs and resources, it is observed from the findings that they are the ones primarily describing the challenges associated with costs as opposed to the primary users – the CHWs, and the end users – the villagers. Although this section is not triangulated by all three sources, it can be observed from the participants' perspectives, that there are numerous costs involved which all act as barrier in the overall progression of the m-health service.

Migration

Another common challenge expressed by four BRAC developers is the issue surrounding migration. Within urban slums, it is common for villagers to migrate to different locations, often without any notice. This poses as a challenge for the m-health service, as BRAC us unable to track the individuals throughout the country. As described by one of the BRAC developers:

> "The migration that happens here, the people here they don't stay in one place, they are floating, from one area to another, to another."

As aforementioned, having other Manoshi centers offering the m-health service would help with this problem. However, most of the time migration is unexpected and spontaneous. The staff

members are therefore uninformed about these relocations. As indicated by one of the BRAC developers this imposes on the overall m-health design:

> "A problem faced is the migration. Suppose a family dividing is going on, because someone is married, she is in another place but we cannot track where she goes, where the family goes. So things are going on. We have our numbers, Manoshi has provided each number, like the household numbers, but still we are facing problem of migration, so this migrating problem is there. So designing the platform is becoming more complicated"

Trying to take into account the number of people migrating in and out of the slum populations is difficult, especially when there is no system in place to track their movement. This therefore affects the m-health application, as some profiles are left incomplete. Although migration is a challenge within this service, it is also a problem that needs to be addressed nationwide.

Inconsistency of health problems

By creating an MNCH program, the services offered have to encompass a wide range of problems. Factors surrounding MNCH come with a variety of issues that are not streamlined or specific. Although the m-health service has been designed to address as many indicators and complications as possible, there are still factors that are beyond the scope of the service. This is expressed by one of the BRAC developers:

> "The problem is health conditions never tell you when there will be a problem, when you are going to be pregnant - these are sudden events - health events are always sudden. So you have to build you software based on the inaccuracy."

To design an application that encompasses all the vital information is an ideal. However with the spontaneity of health events, creating this ideal is ultimately a challenge.

Although the m-health service has been designed to improve the overall MNCH, with only three months of service, there are already many challenges and barriers faced, as described by the participants. Although most of the problems mentioned can be addressed through further

investments, the ability to create the perfect application will continue to be a challenging experience.

Summary of the Challenges and Barriers

Overall, the section demonstrates the variety of challenges and barriers found within the m-health service, as expressed by the participants. It is however important to note that the two challenges: network problems and modes of collection, are the only ones that are triangulated. Although these are both legitimate concerns, the network problem is a national matter that needs to be addressed by the government, and the problems surrounding modes of collection are due to the transition phase that will eventually be resolved by the replacement of the register with the smartphone application. These challenges therefore are not substantial enough to stop the overall development of the m-health service. While there are many different costs associated with the program, which were addressed primarily by the higher-levels of authority: the BRAC developers, these costs surround expansion and sustainability – the expenses that are expected with the implementation and development of new innovative technology. To upkeep this implemented m-health technology, it is therefore assumed that there will need to be further investments to successfully manage such an initiative.

Areas of Improvement

As described in the previous section, with the implementation of the m-health service, there are going to be challenges and barriers, but the recognition of these problems can contribute to improvements. Through the lens of the participants, this section will therefore explore the different areas of improvement. There will be a focus on two different types of improvements: developments to the current m-health system, which highlight the on-going developments that are

expected to be implemented; and the recommended improvements, which are suggestions for future upgrades. Covering these topics provides a comprehensive understanding of where the m-health service intends to be, and what the participants can anticipate in the future.

Current m-health developments

With the infancy of the initiative, there are many components that are mentioned by the participants that are yet to be established. Within this section these developments that are currently being implemented are described, including: one mode of data collection, tracking abilities, the integration of a complete health background for each individual and finally the expansion of the m-health service. As previously mentioned, many of these were emphasized as challenges, which therefore makes it easier to recognize them as current improvements.

<u>One mode of collection:</u>

With the implementation of the smartphone application, there is an understanding that the CHWs have to endure a transition phase whereby data are collected on both the smartphone and their registers. The intentions of this transition phase it to ultimately switch to the better alternative. As described by the participants the better alternative is replacing the register with the smartphone. With two BRAC developers and five CHWs favouring this alternative, there is a common consensus that this improvement will better the m-health service. As described by one of the BRAC developers:

> "If we could get rid of the book, and if we could get all the options that we collect in our books when we go to these households, if it was all put into the mobile phone it would be a lot more convenient."

Similarly this is expressed by the CHWs. The CHWs prefer having the option of one method as opposed to both, as having both increases their overall workload. Recognizing the convenience of the smartphone most CHWs highlight this preference, this is described below:

> "If we could put all of it on the mobile phone, and we could get rid of the book it would be easier – this would make it easier. If they plan on adding anything else to it, then if it were just on the phone it would make it a lot more convenient for us."

Although this suggestion is commonly mentioned among the CHWs as a potential improvement, it is ultimately the program's intent to transition into the smartphone mode of collection. Consequently therefore, the continuous mention of this particular recommendation by these participants highlights the demand to progress forward with the smartphone initiative.

Tracking abilities:

Another current m-health development is the ability to track the CHWs as well as the patients. Although not currently in place, the intent is to use the assistance of the call center as well as the smartphones to appropriately locate the patient in need, and find the nearest facilities and staff that can provide assistance. The BRAC developer describes this below:

> "These are in development, and in Kunipara right now this is in operating phase…It is a Google map, that can show the nearest functional facility, nearest referral center, where the community health worker is. And if you can look at the complicated cases, then you can identify where the complicated cases are and the distance between the facility and the complicated mother. So you can easily calculate that."

By having this system in place, the patient can be referred to the closest location for help. Furthermore it can also show where the closest CHW is, in case the patient needs physical assistance. Additionally this tracking ability also helps with monitoring the CHWs in the field. Although the monitoring system in place, the ability to see this on one screen is still being developed. The BRAC developer further describes this:

> "We haven't started yet the monitoring system. It will be, it is part of our plan. There is GPS in every mobile phone. We know their catchment area, their working area, so if a manager can, when a manager sits in front of his PC, he can see what, which SK is working where and because data will be sent continuously he can't monitor from where the data has been sent."

Having the ability to monitor all the CHWs remotely simplifies a manager's role, as they don't need to physically accompany the CHWs to ensure they are doing their job correctly. As this system develops, having these features will add to the service.

Apart from tracking the CHWs and the facilities surrounding the patient, there is also the intention to track the decisions made by the patient. When a problem arises, often the patients are referred to specific locations or staff, but there is no system in place to show if they followed through with this referral. With the CHWs' responsibility of referring patients, the ability to track these referrals would be helping them. This is indicated below:

> "The mother referrals that we do – if they could have where we refer them, which hospital we are referring to. If that was there that would be good."

This enables the CHW to know if the referral was successful. As described by one of the BRAC developers this system is currently in development:

> "Right now we are also connecting but we are referring directly, so there is no trace whether they are going or not, we are getting information – but it takes time. Now the call center – if the call center is activated and its connected with the mobile system – the call center can track the patients and they can connect patient according to the referral, we can use the referral system. Right now we are piloting the referral system."

By having this system in place, the program can observe if the patients attend to these referrals. This can therefore provide data on the number of completed referrals as well as those that are incomplete, which can ultimately contribute to patient behaviour statistics.

<u>The integration of a complete health background:</u>

As described under challenges and barriers, one problem that exists is the lack of content covered on the smartphone application. By using the smartphone technology, there is the ability to be flexible, so it is possible to upgrade the application to cover more content. With triangulation of data from five BRAC developers, two CHWs and one villager, there is agreement that this should be applied. It is agreed that with more content available on the application, it can potentially improve the service. As described by one of the BRAC developers:

> "Based on the segments, such as we are working on family planning, ANC and PNC, and the rest of the things, we think that if these phases develop accurately and these can perform accurately – now we can go to the next module."

He continues to elaborate on this by stating:

> "There are other modules, such as complicated cases, maternal deaths, and neonatal deaths. We will develop these segments later on."

It is therefore suggested that with successful integration of one module, which in this case includes the ANC, PNC and family planning, the program can move forward to the next module, which will encompass more functionality. There is therefore a general understanding that if all the important components were added to this smartphone application, it would benefit the overall program. As described by one of the CHWs:

> "We collect a lot of information, about the household family planning, there's information about the children, but if there was everything about them in the phone it would be easier – but this hasn't been set yet."

Furthermore, the villagers are also recognizing the need for more information. As described by one of the villagers:

> "If there was more things for my children too, that might make the service better."

With the recent implementation of the m-health service, the program can use these recommendations to understand what other components are needed. These suggestions could

therefore be incorporated into new upgrades that are made for the smartphone application. By taking these recommendations into consideration it can better the overall coverage of the service.

Expansion:

The last intended recommendation is expansion. With only three locations using the m-health service, there is an overall intent to spread to all Manoshi locations. The ability to have this service at different locations will allow for easier communication between the different branches. As described by three BRAC developers and one villager, there is an understanding that the whole community needs to exposure to this m-health service. A BRAC developer expresses this ease below:

> "I would definitely recommend using this elsewhere, starting it together in all branches so that they can work together – this will make it a lot easier for all of us."

By having the ability to communicate with different Manoshi branches through the m-health service, it can help especially when mothers are moving around the country. As indicated by another BRAC developer:

> "If we had all the branches use the same thing then we can communicate between each other better."

As further described by this BRAC developer, if the mother's profile can be easily sent to a different location, this simplifies the transfer of information. But if there is no m-health connection, only the CHWs will have access to the mother's profile within their registers

> "It shouldn't be just the Kunipara mothers – it should be all the mothers. Romna will come, Gulshan will come, I want all eight branches that we have here to use the same service."

The intention to expand to all CHWs, and cover all branches, will streamline the method of communication between different branches. Although this is a recommendation, it is the overall intent for the program to expand so that all branches benefit from the new technology.

Recommended future improvements

The improvements described in the previous section are all in the process of development, indicating the BRAC's intent to integrate them into the service. In this section, the improvements suggested are independent of current developments. These improvements include increasing CHW authority, increasing the number of medical officers, creating a validation system, and lastly population tracking. In this section, all the suggested recommendations are individually stated, so there is no data triangulation. Although these are valid recommendations, with the limited references made about them, they will have minor influence on the program at the moment.

Increasing CHW access:

As previously mentioned, the CHWs do not have access to the information they input into the smartphone application. With access only granted to the senior in charge, specifically the branch manager and the regional manager, the information remains with them. As recommended by one of the BRAC developers, this should change, by providing access to the CHWs as well. The BRAC developer expressed this below:

> "With the mobiles that we are using, in the mobiles the software that is being used, the SKs can't see what they are collecting. I only as the branch manager can see. But for them, they are only responsible for inputting the data. There is a reason for this, that if I can see this I can monitor them. But having it for them will help because they can then see the work that they are doing."

By having access to the information collected, the CHWs can increase their authority by checking to see what they have collected, and if they have inputted the information correctly. This will contribute to their overall accuracy.

Increasing the number of medical officers:

As previously mentioned, there is a lack of medical officers available within the urban slum populations. Increasing their numbers can help deal with cases immediately as opposed to keeping patients waiting for the appropriate referral. As conveyed by a BRAC developer:

> "The medical officers can attend the severe cases. Like whenever emergency call comes, came to us, medical officers are here and there, so they are in the field so if someone is close nearby they can attend the cases, they can attend to the patients"

Having more medical officers available to assist in the field can benefit the overall health system, as there will be more people receiving attention from primary or secondary levels of care, as opposed to attending only to tertiary levels of care.

Validation system:

Although the overall intent for the smartphone application is to increase the overall validity of the data collected, at present there is no way to check the validity of the CHW's advice provided to the patient. As described by a BRAC developer, if there was a method in place that monitored the advice provided by the CHWs, it could show if the appropriate advice was given. The BRAC developer further elaborates on this:

> "Now they are taking their own decision and we can't validate whether its right or not, but if we can establish this system, so this information will come to the server, and what decision, what step she has taken, it will be, could be, monitored

> and whether the decision is right or not – wrong, can also be monitored from there."

Although this has not been implemented, the decisions made by the villagers could be incorporated into the smartphone application. This recommendation could potentially be implemented in the future if there is a collective awareness of its need.

Population tracking

The final recommendation mentioned includes the ability to track the Bangladeshi population. With the recent implementation of the national ID card, one of the BRAC developers suggests that the development of an ID card can help mitigate the migration problem. As they describe below:

> "I can tell you about the ID cards, Bangladesh has the these new ID card, if these are in a digital state then wherever someone is, they can find out. In which area these people are, and what the total population is. This hasn't been put into the system yet"

Although this recommendation can monitor the population and assist with the migration problem, it is a recommendation that can only be addressed nationwide. Therefore in order for this to be implemented it would require government collaboration and public approval.

Summary of the Areas of Improvement

The participants' perspectives describe many of the improvements that are currently in place, some of which answer the aforementioned challenges described in the previous section. With the intention to have one mode of collection, tracking abilities, integration of health backgrounds and expansion, it can be assumed there are many upgrades being developed for the m-health technology. With the infancy of the program, these improvements identify the program's future objectives; ultimately outlining what the program intends to be. In reference to

the recommended future improvements, there is a lack of consistency between the different sources, and although all recommendations are relevant, they are still individual concepts that will need more collective interest from all sources to push for development.

Part VI – Discussion

The analysis of the study findings was able to capture the complexity of the m-health service, as well as provide further understanding of the impact m-health has within urban slum communities in Bangladesh. As described from the perspectives this study was able to define the m-health service as well as highlight four major themes: strengths and benefits, knowledge and awareness, challenges and barriers and finally areas of improvement. The emerging themes found in the data that are discussed in this section provide paradigms of what to expect when implementing such innovations, as well as exemplifies how those involved with the service perceive the technology.

Strengths and Benefits

With the Manoshi program designed to improve MNCH, the introduction of the m-health service has provided both technical benefits and consequential benefits. Most benefits described in the data findings parallel with the existing literature. As identified in the systematic review conducted by Braun *et al.*, (2013), there are four different areas in which m-health could better serve CHWs in improving the delivery of health services: *process improvement and technology development*; *standards and guidelines*; *education and training*; and *leadership and management*. With most of the technical benefits surrounding the CHWs' responsibilities, the ease of communication, faster response times, simplification of tasks, enhanced access to medical history, categorization of severity, increased accuracy and increased savings, all primarily associate with the *process improvement and technology development.* Similarly the consequential

benefits: novelty of the program, trust in program, empowerment and improved health care system associate primarily with *leadership and management.* This is further discussed below.

Technical Benefits

By focusing on the ease of communication – one of the major technical strengths of the m-health service, is an understanding that the villagers have been informed about the appropriate methods for instant communication with the CHWs and/or the call center. Having the ability to communicate when necessary allows problems to be solved in a timely manner, as described by Braun *et al.*, (2013) under *process improvement and technology development*. Instead of waiting for the CHWs to visit during household visits, this service allows villagers to take actions into their own hands by using this mobile-based technology for immediate access to care. When addressing the technical benefit of faster response times – another major strength of the service, it also relates to the *process improvement and technology development* described in Braun *et al.*, review. By using mobile phones, villagers can expect that with every call there will be a rapid response, whereby receiving the appropriate steps of action when faced with a problem. This rapid response provided by the CHWs or call center, whether it is the immediate provision of advice, or referral to the doctor or hospital, offers the villager an instant feedback. Furthermore, as described under the m-health service description, the referral process and program support is commonly understood by all CHWs, whereby the CHWs know where and whom to go to when they are unable to resolve the problems themselves. These protocols that the CHW abides by, correlates with the *standard and guidelines* described by Braun *et al.*, (2013). The CHWs therefore know that they can get immediate access and support from their superior when necessary, allowing them to provide rapid responses to the community.

Another technical benefit that supports *process improvement and technology development* is the simplification of tasks. With the transition from the register to the smartphone application during data collection, a common understanding among the participants is that the data are resistant to loss. Apart from being a physical burden, the registers also have a higher chance of being lost or damaged. By using the smartphone application, the CHWs can therefore eliminate the risk of losing any information, as there are store and foreword capabilities available. Additionally, the simplification of tasks is also noted in the similar study conducted by Alam *et al.* (2010), on the impact of BRAC's m-health pilot initiative. As described in the study, the CHWs found the technology simpler and more acceptable to use. This parallels with the data findings, as common consensus from all participants was that the smartphone application was the preferred method for data collection.

The technical benefits: enhanced access to medical history and categorization of severity again fall under *process improvement and technology development.* Although the data findings suggest no data triangulation, the findings highlight the quality of the data being collected. By having access to medical history, there is recognition that this information can be stored and accessed over time. Previously, trying to gain access to medical history would involve searching through the out dated registers, however with the implementation of the smartphone application, there is immediate access to patients' medical history. Similarly the categorization of severity is another example of the quality data, as it allows CHWs to identify a high-risk patient and provide the appropriate advice. The process in which data are collected over the smartphone application, allows calculations to be made instantaneously, which automatically classifies the women as high-risk, low-risk or medium-risk. It is therefore the ability to have these technical benefits that can increase the quality of data received, which contributes to process improvements.

When looking at increased accuracy, although only mentioned by the BRAC developers, it suggested that the smartphone application provides a more valid representation of the community as opposed to using the paper-based method of collection. As described in the data findings, the paper-based method resulted to higher error rates; reducing the overall credibility of the data. By implementing a smartphone application that rectifies these issues, it represents *process improvement and technology development,* as the data are likely of higher quality and resistance to any potential errors.

Another strength in the m-health program is the ability for the villagers to have access to cost-effective solutions. This is supported by the qualitative study by Ashraf, *et al.*, 2010. With the introduction of an m-health technology, it allowed patients to have access to healthcare at their fingertips allowing patients to overcome issues involving travelling to medical facilities and having unnecessary costs. This is an important component that can affect the overall health system. Rather than having villagers visit tertiary levels of care, such as hospitals and doctors directly, the CHWs can use the m-health service to provide remote medical assistance, and if necessary, they can also use the referral system to provide the villagers with higher levels of medical attention that is safe and cost-effective. The m-health system therefore ensures the villagers reduced medical expenditures, as they no longer have to immediately attend to higher levels of care, instead they can rely on a phone call to receive the relevant assistance.

By looking at all technical benefits of the m-health service, most fall into the process and improvement category. Within this category CHWs benefit from high quality and timely data that is resistant to error and loss. Furthermore, with these benefits they can provide rapid responses to the community. The major technical strengths of the service ease of communication, faster response times, and simplification of tasks, all of which are triangulated among all three sources,

emphasize the process and improvement category, suggesting how the implementation of an m-health service can positively influence MNCH.

Consequential Benefits

As described the consequential benefits are the wider impacts experienced from the m-health service. By implementing an m-health service in a developing country, specifically an urban slum, there is automatically a novelty attached to the service. With triangulated data found regarding this benefit, it suggests that many participants enjoy the service purely due to its novelty. Although there no literature on this phenomenon, it can be assumed that new innovations bring a sense of curiosity and excitement, especially to those who have limited access to the technology. When looking at consequential benefits: trust in program and empowerment, both of these factor into the category of *leadership and management* as described by Braun *et al.*, (2013). Recognizing the CHWs as the frontline workers and primary vehicles that drive the m-health service places a lot of responsibility on them. This responsibility allows them to be independent within their roles, empowering them within the community. By having this status within the community, they act as strong role models, whereby building relationships with the villagers and increasing the villagers' trust in the program. With the community observing all that is being done by the CHWs, there is a sense of respect as well as trust built from their actions. As defined under the m-health service description, the roles and responsibilities of the CHW cater to the community's well being. By providing constant assistance via mobile phones or through household visits, they are able to provide the appropriate level of care and assistance, making them central components to the overall m-health service delivery.

Finally, the sum of all these benefits adds towards an improved healthcare system. Although only mentioned by the BRAC developers, the ability to provide remote assistance over

the phone, partially attends to primary and secondary levels of care. With a general dependence on tertiary levels of care within the country, this service can reduce this overall burden, benefiting the healthcare system. When looking at the literature, this falls into the groups: *disease surveillance*, and *disease management* described in the review conducted by Deglise, *et al.,* (2012a). Although the review provides examples of short message service (SMS) as the primary means of communication, within this study, the ability to have remote assistance from the CHWs over the mobile phone, especially during emergency situations allows for efficient public health surveillance as well as overall management of community health. With the CHWs being the primary point of contact they are able to know exactly what is going on within their community, and how to appropriately address the situation. By having the option available to discuss matters with CHWs, it eliminates the need of always sending the patient to the doctor or the hospital, reducing the dependence on tertiary levels of care. Furthermore, by having real time tracking capabilities available during data collection, as mentioned in the m-health service description, BRAC developers are able to gain instant updates on the community health. Apart from the smartphone facilitating this health surveillance, the BRAC developers can also take the appropriate steps to manage and address these health concerns.

Along with *disease surveillance* and *disease management,* the introduction of the smartphone application has allowed for faster data collection methods providing more time for knowledge sharing between the CHWs and the villagers. This goes back to the review by Braun *et al.*, (2013), as this gives the opportunity for *process improvements* due to the rapid responses and the timely manner in which the villagers are able to gain further advice from the CHWs by sharing their problems.

It is apparent that the consequential benefits influence the community on a wider scale, whereby *leadership and management* (Braun *et al.*, 2013) and *disease surveillance* and *disease*

management (Deglise, *et al.,* 2012a) all play significant roles. By empowering the CHWs, and using them to build trust in the program, the CHWs inherit the responsibility for ensuring the overall well being of the community. This collectively benefits the overall healthcare dynamic, as CHWs are able to alleviate problems earlier.

Knowledge of the Service

CHWs are obliged to inform their clients about the m-health service. This involves educating clients when using the m-health service, as well as educating any individuals external to the service. This section will therefore discuss educating the community, the ability to increase awareness, the diffusion of m-health innovation and lastly the lack of community awareness on their personal security.

Educating the community

When using the m-health service, it is the responsibility of the CHWs to educate their clients on the different methods of contact when a problem arises and when using the smartphone application for data collection, this enables their clients to understand the overall purpose and intent of the service. Apart from their own clientele, the CHWs are also responsible in educating the external people with interests; these include other CHWs or villagers who have not used the service. Having this responsibility, brings attention to the CHWs *leadership and management* skills, the CHWs adherence to the *standards and guidelines* as well as their ability to provide *education and training* as mentioned in the review by Braun *et al.*, (2013). With a large number of CHWs describing these responsibilities, it can be assumed a common foundation incorporates their roles as primary educators within the community. As described by the BRAC developers, they are the "vehicles" of the program. With these duties, it enhances their leadership skills,

adding to their overall sense of empowerment. Although the literature on *education and training* focuses on the methods in which CHWs are trained and educated, it is the ability for them to accurately relay this message to the community that brings attentions to their levels of *education and training*. By having a program support system in place as described in the m-health description, the CHWs can therefore have immediate access to their superiors ensuring that they are providing accurate information regarding the service to the community. There is therefore a flow of information that is transferred through the CHWs, from the higher levels of authority right to the end users, the villagers.

Increasing community awareness

Although limited literature pertains to m-health in promoting awareness, this study is able to capture how villagers have the opportunity to learn more about their health. Within Clemmons & Shillingi (2009) study, they were able to show how a text message helpline service provided awareness about HIV/AIDS. In a similar fashion, this initiative allows villagers to call directly to the CHWs or the call center to receive helpline service where they can receive information regarding MNCH. As described in the m-health service description, with the existence of the referral process, the beneficiaries are communicating with appropriate medical assistance, where they can ask questions about any problems or concerns. With the CHWs providing the villagers the means to communicate with these contacts, it allows them to gain immediate assistance, provision of an appropriate solution, as well as awareness about their overall health and well-being.

Diffusion of innovation

As described the CHWs are responsible to educate the community about the m-health innovation. As defined by Rogers (2010, p. 5) "Diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system." When applying this to the m-health service being studied, the social members communicate the information about this m-health innovation from the BRAC developers, through the CHWs and finally to the villagers. The ways in which information is moved through this chain, is the diffusion of innovation (Rogers, 2010). Within the data findings, majority of the m-health service is managed and maintained by higher levels of authority, specifically the BRAC developers and sometimes the CHWs. Although this could be a reflection of the different education levels as described in the demographic data, it can be assumed that the BRAC developers have the most knowledge on the service in comparison to the villagers. It is however the communities knowledge that reflect the diffusion of innovation. Although it is assumed that the CHWs' clients will be exposed to the m-health innovation, it is the also the external interest (those who do not have access to the innovation), that is able to capture the diffusion of this innovation. With only three months into program implementation, the triangulation of data that exists regarding the external interest for the service is able to highlight the community's curiosity for the program, emphasizing the overall speed in which the diffusion of innovation is occurring at the community level. Looking at the diffusion of innovation model (Figure 6) it can be suggested that the participants within this group belong with in the "early adopters" section, whereby they are initially getting introduced to the technology. With three months into program implementation, it can be assumed that all participants are still within the *early adopters' phase,* whereby each are still familiarizing themselves with the service. Although the BRAC developers have the most

knowledge on the service, there is still information transpiring through the community, that demonstrates the diffusion of this m-health innovation.

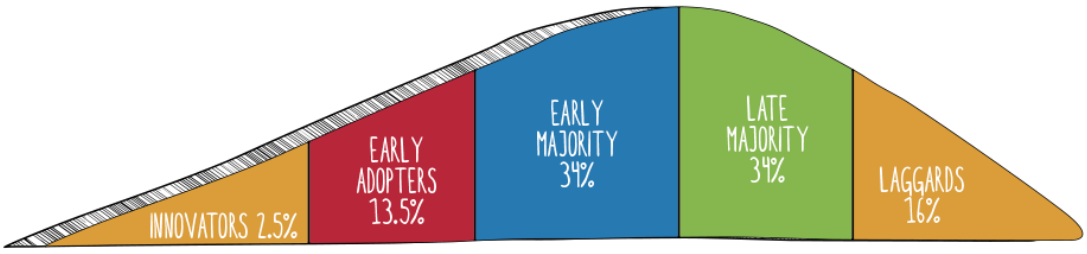

Figure 6: Diffusion of Innovation Model

Retrieved from Essential Marketing Models. Retrieved July 21, 2014 from http://bit.ly/smartmodels

Lack of community awareness on their personal security

As described the diffusion of innovation involved within this m-health service is the transfer of information from higher levels of authority: the BRAC developers, to the end users: the villagers, with the CHWs being the medium of this knowledge transfer. Although the content provided has described the overall purpose and intent of the service to the villagers, there is still a lack of community awareness on their personal security and confidentiality. Although there may be protocols in place that limits the access to client information, from the data findings there is no mention of any personal confidentiality or security measures that are currently in place for the villagers' information. With the villagers providing the requested data to the CHWs, they specifically are unaware of where the information is going and who has access to it. With limited literature found on the security of m-health initiatives the systematic review conducted by Gurman, Rubin & Roess (2012), was able to show that almost half of the studies included in the review ensured the patients privacy, suggesting that it is an important feature within m-health technology. Furthermore a refereed paper by Fraser *et al.*, (2005) on the implementation of electronic medical records in developing countries highlights the need to ensure data security and

confidentiality. Although electronic medical records are different to the m-health practice, the content that is provided by the end users is still confidential information in both accounts. As described by Fraser *et al.*, (2005), all developing countries have different approaches to privacy, some include higher levels of security and some completely disregard the sensitivity of the medical information. This is an important component that is missing when disseminating the m-health information to the community. This therefore is an additional component that the BRAC developers and CHWs should keep in in mind for future developments, to ensure that they educate their clients fully on how their personal information is handled once inputted and stored within the m-health system.

Challenges and Barriers

The implementation of an innovative technology – the m-health technology has barriers and challenges, especially during its pilot phase. Capturing these challenges helps identify can help better the service. As described in the data findings, the m-health service includes a wide array of problems that include network problems, modes of collection, costs involved, migration and the inconsistency of health problems. Although each problem is unique, collectively these problems stem from the infancy of the program.

Looking at the biggest challenge – the network problem, it is understood that this a nationwide problem as opposed to the service itself. With six mobile providers within the country, and an annual growth rate of 13.8% of active mobile subscribers, there are a growing percentage of people who use mobile phones (BTRC, 2014). Additionally looking at the demographic data, only two villagers did not have their own personal mobile phone, but had access to their husbands' phones. The statistics provided by BRTC, recognize the increased access to personal mobile phones within Bangladesh. Although there is an increase of mobile

usage, there are still locations that have limited access to the network, as described in the findings. This could be attributed to the growing population, or the high density rates found within urban slums.

The next challenge, which was commonly referred to by all participants, is the dual modes of collection. Although this was mentioned as a challenge, it is expected that dual modes exist during implementation of an innovative technology. Having the paper-based application running parallel to the smartphone application provides back up support in case the technology fails. This transition phase is therefore is expected, and necessary for successful integration. This therefore is a problem that can only be eliminated once the smartphone application has achieved its overall objectives.

Another problem that was mentioned consists of the overall costs. Even though the BRAC developers primarily state this, it is the higher levels of authority that are exposed to the overall expenditures. The costs to implement such an innovative technology are high, especially when introducing to an urban slum population where mobile technology is limited. Although Mahmud, *et al.* (2010), and Alam *et al.* (2010), found that in their studies there were cost reductions in the providing the service by introducing this m-health technology, Gurman, Rubin & Roess (2012) were able to highlight that most studies still lacked long-term evaluation and cost-benefit analysis. With a variety of different costs associated with the service, including the initial investment, the smartphone costs, the evolving technology costs and the resources required, it is expected that they act as barrier for m-health development, especially when there is a lack of references available to compare against. As mentioned by Chib, van Velhoven & Car (2014) in another systematic review, although there are numerous initiatives being implemented with m-health technology, there is still a lack of information of its overall effectiveness, especially since there is no gold standard in place that can be replicated for the implementation of

such a technology. With each initiative being unique and having their own set of objectives, it is impossible to make this generalization

The challenge of migration is another problem that needs to be addressed. In the context of an urban slum population where there is no census and high mobility rates. Migration plays a significant part within the m-health service, as many of the clients are lost over time, which constrains the developers from understanding the overall effectiveness of the program. Additionally, with the m-health service designed to address specific indicators and complications, the inconsistencies of health problems, as mentioned in the data findings, can act as a challenge when determining the effectiveness of the m-health service. This is due to the fact that some specific issues may be overlooked and disregarded. In order to address these problems, the application has to be developed to encompass all the necessary information, however once again, with a lack of literature available m-health development, it prevents the program from knowing exactly was components are necessary.

The challenges discussed within the data findings strengthen the idea that m-health research is still in its preliminary stages. With limited data and literature addressing the appropriate steps to take when implementing such an innovation, it prevents any m-health program from having successful integration right away. As mentioned by Chib, van Velhoven & Car (2014) in order to successfully understand the importance of this technology, there needs to be more reported literature on m-health interventions that focus on how they contribute to established health indicators and how they benefit from long term cost-effectiveness. By having a greater volume of literature that addresses these issues, as well as establishing measurement standards in place, as mentioned by Chib, van Velhoven & Car, m-health developers will be able to overcome and understand most of these challenges.

Areas of Improvement

Successful integration of an m-health program comes with many challenges and barriers, especially when the technology is still in its introductory stages. As aforementioned, the lack of literature available and the uniqueness of every m-health program, prevents the program developers from fully understanding the essential steps for successful integration. Although there is a lack of data triangulation within this section, the data findings identify potential areas of growth that can assist in the m-health development. Within this section these areas will be discussed, which will be followed with a recommended course of action. Initially this section will discuss the current improvements in place and then the recommended improvements, which are the suggestions made by the participants regarding what they want integrated into the service.

Current m-health developments

The current m-health developments include one mode of data collection, tracking abilities, integration of health background for each individual and expansion of the service. With all these developments currently in motion, there is recognition that these objectives will be met in the near future. With these ambitious developments in place, all of which are equally important, it is integral to focus on the sequence in which they occur so that it could better assist in the overall m-health service development. Initially it is important to start with the developments that need to be integrated within the application, this will therefore be components that are added to the software. Starting with tracking abilities, this involves tracking the CHWs as well as the patients within the urban slums. By using the m-health technology, the intent of the tracking system is to identify the location of the problem and then identify the closest CHW. This identified CHW can then be contacted to provide immediate assistance to the individual with the problem. Additionally, the intent to track the decisions is made by the patient. This would be

applicable when the patient is provided with a referral. The tracking system can therefore indicate whether or not the patient complied with the advice provided by the CHW or the m-health service. In addition to the tracking component, there is also the intent to incorporate more content within the smartphone application; this would therefore involve expanding from the three options that exist currently (ANC, PNC and family planning) to incorporate more health indicators. As mentioned in the data findings, these developments are currently in place, however by integrating this into the software first prior to expansion, will give the developers the opportunity to test out the overall applicability. The next two developments mentioned include one mode of collection and expansion of services. Although the one mode of collection was frequently mentioned among BRAC developers and especially CHWs, the overall purpose of running both methods of data collection is to provide back-up support in case the software fails. This therefore means that the CHWs have to use both methods until the software is designed to incorporate all the necessary information. Once this has been achieved, the elimination of the registries will be more valid. Consequently once the software has been established, the next steps would involve expansion. Although there is an assumption that the service would better serve the community if all other branches communicated on this m-health platform, there is more risk involved. This is due to the fact that once the system has been set up in alternative locations, any modifications to the software would require making appropriate changes to all locations, which would be increase the overall burden of work. It is therefore important to have a framework prior to expansion beyond the pilot sites.

Recommended future improvements

The recommended future improvements are suggestions made by the participants that could be incorporated into the service. These recommendations include: increasing CHW access,

increasing the number of medical officers, incorporating a validation system and incorporating a population tracking system. Seeing that these are suggestions made by the participants, it is apparent that these recommendations play a significantly less important role within the development of the m-health service in comparison to the developments currently in place. With these suggestions being individual recommendations, it will require more collective participation in order to be implemented within the service. Providing the CHW access to the content they collected on the smartphone application during household visits is a beneficial component for them, especially when the CHWs want to verify the data that they have collected. It is important to note however, that this may affect the security of the data collected, as well as interfere with the real-time monitoring system that is maintained by the BRAC developers. Another suggestion mentioned involves increasing the number of medical officers. This would be a beneficial addition to the service as more assistance could be provided on the field, however with the intention of saving on costs with this m-health service, hiring of more staff members could ultimately be an additional expense that may not be necessarily required once there is full implementation of the m-health service. The remaining recommendations, although beneficial, are a challenge to implement within the m-health service. To create a validation system that checks the validity of the CHWs advice would involve integrating a whole new component to the software that would be separate to the existing data collection application. Additionally attempting to create a population tracking system, although necessary, would be challenging, as it would have to be implemented nationwide. This would therefore encompass government assistance as well the overall public participation. Although these suggestions are valid, they are difficult to implement within an m-health service, especially when it is in the initial stages of development. Once the m-health system has advanced and been stabilized with the current developments, the aforementioned recommendations can be put into place if and when necessary.

Part VII – Study Limitations

Conducting a qualitative study answers the how" and "why" questions of an intervention, (Yin, 2009). Looking at the data findings, this exploratory study has provided the preliminary fundamentals that can ultimately contribute to further study designs (Jaeger & Halliday. 1998; Marshall & Rossman, 1999). It is however integral to identify the study limitations to ensure the validity of the study.

With the m-health service being piloted within the urban slum of Kunipara, a restricted number of participants were available for the study sample. A total of 21 participants, (seven were BRAC developers, seven CHWs and seven villagers) reduces the overall generalizability of the study. Additionally, when looking specifically at the villagers, there were only women interviewed; this therefore further reduces the generalizability. It is, however, important to note that most of the clients using the m-health service were women, primarily because the service catered to MNCH, however having perspectives of men could have added value to the overall knowledge of the service.

As mentioned by Yin (2009) conducting semi-structured interviews has its own set of weaknesses that include susceptibility to biases. As previously mentioned recall bias, response bias and reflexivity (social desirability bias) is common. Within the study, many of the participants, especially the villagers were more inclined to provide socially desirable responses. In this study, the CHWs were responsible for finding the appropriate villagers to take part in the study, this method of snowball/chain sampling, whereby study participants guide the interviewer to other information rich sources (Suri, 2011) can lead to biases. The villagers, who participated, therefore may have provided responses that were expected by the interviewer. Although all interviews were performed privately, the close proximity of the CHW could have also affected

the villager's responses. Furthermore, the affiliation with the CHW may have prevented them from providing truthful accounts, as the villager may have wanted to keep the CHW-patient relationship intact.

Another limitation included the language. Although the interviewer spoke the native language Bangla, some participants, especially the villagers, may have had difficulty comprehending the questions during the interview process. This may have affected their overall responses. Furthermore, with this language barrier, some participants could have been susceptible to interviewer bias – whereby the opinion of the interviewer is apparent during the interview process (Harrell & Bradley, 2009). To ensure this was maintained, the interview guidelines maintained neutrality.

Part VIII – Conclusion

After the analysis and discussion of the study findings, a picture evolved that added to understanding of the internal dynamic of an m-health system. By taking a qualitative look into the perspectives of the BRAC developers, the CHWs as well as the villagers, it provided insight into the perception of different levels associated with the service, providing a complete understanding of how the m-health service worked. By interviewing the three different sources, this paper was able to define the m-health service, as well as highlight the reoccurring themes, which include strengths and benefits, knowledge of service, challenges and barriers and finally areas of improvement.

The implementation of the m-health service has brought many advantages that impact each of the different sources. As described in the discussion, many of these advantages are consistent with the existing literature, whereby there are similar experiences with alternative m-health initiatives. Within this initiative, the BRAC developers are able to gain from a more effective delivery of healthcare, the CHWs gain from simplified roles and responsibilities, and finally the villagers benefit from an accessible and remote service. This m-health service is able to provide healthcare at each individual's fingertips, and with the growing numbers of mobile subscribers within the country, this can really influence the healthcare system. As described, the m-health service has capabilities that go beyond the technical components of the service. CHWs are empowered as individuals as they have the responsibility to take care of their community. Furthermore, their responsibility transpires into the establishment of trust for the program. Additionally educating the community about the service allows the innovation to disseminate from the higher levels of authority all the way to the end users. With the CHWs being the primary vehicles of this knowledge transfer, they further take on the role as educators within the

community, exposing the service to their clients as well as those who are curious to learn more about it. Even with the community being taught about the m-health service, there is still a lack of instruction provided regarding their privacy and confidentiality. With the villagers providing personal information, it is important that the program informs the villagers about their personal security. Although this was not mentioned throughout the study, it is something that could be recommended as the service moves forward. This will not only strengthen the villagers' perception on their personal security, but will also enrich the service, as it will reduce the risk of any mismanaged personal information.

With any innovation it is likely that there will be challenges and barriers. In contrast to strengths and benefits, many of the challenges found in the findings are not supported by existing literature. One of the overall challenges that are faced by many health initiatives is the lack of national or local census data. Most other identified challenges stem from the infancy of the innovation. The literature review revealed numerous studies that focused on at m-health initiatives, but there was lack of literature available on its overall effectiveness and long-term sustainability. With these studies, although there is overlap with the strengths (as mentioned previously), with the challenges, they are all unique to the service. By looking specifically at the problems described from this m-health service, which include network problems, costs, migration and inconsistency of health, it is can be assumed that most are unique to the nature of the service. As described by Chib, van Velhoven & Car (2014) with no template to go by, the overall effectiveness of the service cannot be measured. It is therefore necessary to continue research within this discipline to gain solid examples of long-term benefits and cost-effectiveness.

From the data findings, it is apparent that in order to ensure sustainability and growth, the m-health service has to achieve their current objectives in the appropriate sequence. Incorporating a plan that can assist them in their overall growth, can ultimately allow them to overcome their

challenges and achieve their future recommendations. As described there is the intention of introducing a tracking system that monitors the CHWs and tracks the decisions made by the patients. Additionally there is the intent to incorporate a more comprehensive medical background for each individual within the smartphone application. These therefore should take priority before the any of the other objectives, which include one mode of collection and expansion. Establishing an effective smartphone application on a smaller scale, that has all the necessary indicators and information, should be addressed first, as this will avoid large changes in the future. Once the application has been established, then the next appropriate steps can be taken. This would therefore involve the full replacement of the registers with the smartphone device, and eventually further coverage nationwide. Other recommendations could come into place once the application is fully integrated within the community and there is a large collective interest for any change.

With only three months of existence, the m-health service developed by BRAC has the potential and capacity to change the healthcare system in Bangladesh. With the diffusion of this innovation reaching the community level, it is evident that there is an overall curiosity and acceptance for this initiative. Although there are many challenges that are expected during the implementayion of an m-health service, the overall strengths of the service compensate for these issues, by providing a more effective and accessible form of healthcare. Additionally with the use of this technology, it allows the program to participate in "leapfrogging," a term used when the normal progression of using landline technology is avoided, and instead modern, innovative technologies are implemented (Bastawrous & Armstrong, 2013). With urban slums being common within most developing countries, this study serves as an example of what to expect when implementing this type of m-health service. By accumulating the different perspectives of those involved with the service, it is able to provide a more complete representation of the facets

involved when implementing m-health innovation. Although further quantitative studies are necessary to understand the overall effectiveness of this m-health service, this study is able to provide the preliminary foundations for future m-health research. With the implementation of any health innovation there are always implications beyond the intervention, but these pilot projects are important in order to establish issue of feasibility and identify necessary areas that have to be addressed before system wide implementation.

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Appendix

Appendix 1: Consent Form

Sameen Ahmed, BSc, (MSc Student), Andrea Baumann, RN, PhD (PI), Norman Archer, M.S. PhD, Michael Ladouceur, RN, MPH

Study Purpose
You are invited to take part in a research study looking at the use of mobile health (m-health) services in urban slum population in Bangladesh, specifically BRAC's m-health service for maternal, neonatal and child healthcare (MNCH). By discussing the service with you, it will help with understanding the m-health technology and how it can assist the Bangladeshi healthcare system.

Participant Role
As a participant, you will be asked to complete a questionnaire and to take part in a semi-structured interview with the researcher. Questions will focus on the m-health service, the resources/guidelines used when the service is provided and the individual opinions about the service. The interview will be digitally recorded and will last between 45 to 60 minutes.

Study Risks
Participants will face no harm when taking part in the study. All the names of participants will be replaced with identification codes, which will allow participants and their responses to remain anonymous throughout the study. Participants will have the freedom to skip questions if they do not wish to answer, and will have the option to stop the study at anytime with no consequences.

Study Benefits
After completion of the study, the results found will be summarized and discussed with the BRAC developers and CHWs to find potential recommendations that could be used for future m-health developments. If you would like to receive the study results please do let me know and I will gladly provide them.

Confidentiality
Confidentiality will be maintained through out the study, by creating a coding system that keeps participants anonymous. All digital recordings will be saved on a password-protected recording device and all hard copies of questionnaires and consent forms will be stored in a locked cabinet in the researcher's home. All documents/files inputted in the

researchers computer will be saved on a password-protected computer. Five years after the study is complete, all electronic files will be deleted and all paper documents will be shredded and discarded.

Consent to participate

After reading the information regarding this study, I know of the purpose of the study and the benefits and risks that I can come across. I know that this interview will involve providing my opinions on the m-health service and I know that this will be digitally recorded. I know my confidentiality will be maintained and that I have the freedom to withdraw at any time of the study without any consequences. If I have any further questions I will contact the researcher directly.

I will receive a signed copy of this form.

Name of Participant	Signature	Date
Research Team Member	Signature	Date
Person Obtaining Consent	Signature	Date

If I have any questions about this interview, I understand my contact is Sameen Ahmed, Masters of Global Health Program Student, McMaster University at (905)525-9140 ahmeds45@mcmaster.ca.

Appendix 2: Verbal Consent Guidelines

Introduction:

Hello. My name is *Sameen Ahmed.* I am carrying out interviews on the mobile health services provided by the Manoshi program under BRAC. This is for a student project at McMaster University in Canada. I'm working with Dr. Andrea Baumann a professor at McMaster University. I was told by the BRAC organization that your community had access to this service and would like to take the time to talk with you about the service.

Study procedures:

I will ask you to fill out a questionnaire about yourself, including your age, employment, education and your access to a phone. I will then ask a few questions about the service, about how it is provided by the community health workers and lastly your perceptions about the service. The interview should take around 20-40 minutes and I will ask you to let me record the interview with an audiotape.

Are there any risks to doing this study?

There is a chance that you might feel uncomfortable talking about your own opinions about the service provided, in the circumstance that you do, please feel free to skip any questions or stop at any time. In my report, I will not use any names of the people I interview, as identification numbers will replace these. This means that people will not be able to identify you or what you have said.

Are there any benefits in doing this study?

I want to understand what can be done to better develop m-health services for MNCH in Bangladesh. I would like to understand how it works, the challenges and how I can make the service better.

Voluntary participation:

Please understand that you can choose to participate in this study, if you decide to stop at any time or would like to skip a question there will be no problems. If you have any questions about this study or want more information you can call or e-mail me. My number is +8801852022222 and my e-mail is ahmeds45@mcmaster.ca.

This is a McMaster Research Ethics Board reviewed study. If you have questions about this interview you may call or e-mail the McMaster Research Ethics Board at:

McMaster Research Ethics Board Secretariat

Telephone: (905) 525-9140 ext. 23142

c/o Research Office for Administration, Development & Support (ROADS)

E-mail: ethicsoffice@mcmaster.ca

If you would like me to share the answers of this study, please do let me know and I will gladly send them to your at your convenience.

Consent:

Please let me know if you have any more questions? If you chose to agree to provide your verbal consent, I will record your approval, and then I will begin the interview.

- *if yes – start recording and start study*
- *if no – thank the participant for their time*

Appendix 3: Demographic Data Questionnaire

ID Number ……..

1. City/District ……
2. Gender: Male □ Female □
3. What age group do you belong to?

18-25	☐	26-30	☐
31-35	☐	36-40	☐
41-45	☐	46-50	☐
51-65	☐	66-70	☐
71+	☐		

4. Highest level of education

Primary School Certificate	☐	Higher Secondary Certificate	☐
Secondary School Certificate	☐	University or higher education	☐

5. Number of residents per household

1-5	☐	11-15	☐
6-10	☐	Over 16	☐

6. What is your occupation type/livelihood

Agriculture/Forestry/Mining	☐	Construction	☐
Manufacturing	☐	Education	☐
Transportation/Storage Including postal/courier	☐	Wholesale/Retail trade, Repair of motor vehicles	☐

7. Geographic accessibility to nearest aid

   a. *Hospital* ……

   b. *Tele-center* ……

   c. *Community Centre* ……

8. Mobile Ownership

   a. Yes □

   b. No □

   → If No: closest access to phone ……

Appendix 4: CHW Interview Guide

Research Team:

Sameen Ahmed, BSc, (MSc Student), Andrea Baumann, RN, PhD (PI), Norman Archer, M.S. PhD, Michael Ladouceur, RN, MPH

Foreword:

Thank you for taking your time to take part in this interview. If at any point of time you during this interview you feel uncomfortable answering a question, please feel free to skip to the next question. If you choose to stop at any time, please do let me know and we will discontinue the interview.

As mentioned I am interested in BRAC's m-health initiative offered to the urban slum population of Korail in Dhaka. I have a few questions focusing on this service, and appreciate all the time you have provided in gaining these insights.

Questions:

Services

1. How do people within the community hear about your services?
   Probes:
   - How many visits do you conduct on an average day?
   - Is your service commonly used? Is your service repeatedly used?
   - Is there a demand for this service within your locality?

2. How do interested clients get in contact with your service?
   Probes:
   - Are you easily accessible within your community?
   - What is the best way for new clients to contact you? What is the most commonly used method of contact?

3. Please describe a typical day using the m-health application?
   Probes:
   - Please describe the services you offer?
   - What are the services most requested?
   - What services do you believe are missing?

4. Describe the features on you m-health device?
   Probes:
   - What are each of the features required for?
   - Which feature is the most frequently used and why?

- Which do you find the most useful?
- How do you think this tool benefits healthcare?

Training and Guidelines:

5. From the day you started till present day, please describe your entire training process?
   Probes:
   - Do you have ongoing training?
   - How is this training facilitated?

6. If you encounter any problems while you are working, what is the procedure?
   Probes:
   - Do you have a point of contact? A support system?
   - How do you contact them?

Perspectives:

7. Why do you believe this type of service is valuable within your community?
   Probes:
   - What do you think are the primary benefits?
   - How would you recommend this service to other people?
   - What would you recommend and why?

8. How does this service associate with hospital, clinics, tele-centers or community centers?
   - Is there a channel system in place?

9. What are the main potential barriers in effectively providing this service?
   Probes:
   - Do you find any technical difficulties?

10. What would you recommend for this service in the future?
    Probes:
    - What would you add, what would you change?

Appendix 5: Bangladeshi Villager Interview Guide

Research Team:

Sameen Ahmed, BSc, (MSc Student), Andrea Baumann, RN, PhD (PI), Norman Archer, M.S. PhD, Michael Ladouceur, RN, MPH

Foreword:

Thank you for taking your time to take part in this interview. If at any point of time you during this interview you feel uncomfortable answering a question, please feel free to skip to the next question. If you choose to stop at any time, please do let me know and we will discontinue the interview.

As mentioned I am interested in BRAC's m-health initiative offered to the urban slum population of Korail in Dhaka. I have a few questions focusing on this service, and appreciate all the time you have provided in gaining these insights.

Questions:

Services

1. How did you, or someone in your family hear about this service?
    - Is this service commonly used? Is this service repeatedly used?
    - Is there a demand for this service within your community?

2. How do interested clients get in touch with this service?
    Probes:
    - Are they easily accessible within your community?
    - What is the best way for new clients to contact them? What is the most commonly used method of contact?

3. Please describe the m-health services offered? Can you provide examples of when you used their service?
    Probes:
    - What are the services most requested?
    - What services do you believe are missing?

4. What features are used in the m-health device to provide you with information?
    Probes:
    - What are each of the features required for?
    - Which feature is the most frequently used and why?
    - Which feature do you find the most useful?
    - How do you think these tools benefit your healthcare?

Training and Guidelines:

5. When using the service, do you find that the information provided is up-to-date?
   Probes:
   - What are your thoughts regarding the content of the information received?

6. Have you experiences any problems when working with this service? If so, how and what does the CHWs do to rectify the problem?
   Probes:
   - Does she/he use any alternative method of finding information?
   - Does she/he contact anyone?

Perspectives:

7. Why do you believe this type of service is valuable within your community?
   Probes:
   - What do you think are the primary benefits?
   - Would you recommend this service to other people/friends/family?
   - What would you recommend and why?

8. How do you think this service associates with hospital, clinics, tele-centers or community centers?
   - Is there a channeled system that helps direct you where to go if further attention is needed?

9. What are the main potential barriers in effectively providing this service?
   Probes:
   - Did you/CHW experience any technical difficulties?

10. What would you recommend for this service in the future?
    Probes:
    - What would you add, what would you change?

Appendix 6: BRAC Employee Interview Guide

Research Team:

Sameen Ahmed, BSc, (MSc Student), Andrea Baumann, RN, PhD (PI), Norman Archer,

M.S. PhD, Michael Ladouceur, RN, MPH

Foreword:

Thank you for taking your time to take part in this interview. If at any point of time you during this interview you feel uncomfortable answering a question, please feel free to skip to the next question. If you choose to stop at any time, please do let me know and we will discontinue the interview.

As mentioned I am interested in BRAC's m-health initiative offered to the urban slum population of Korail in Dhaka. I have a few questions focusing on this service, and appreciate all the time you have provided in gaining these insights.

Questions:

Services

1. How do people in the community hear about this service?
    - Is this service commonly used? Is this service repeatedly used?
    - Is there a demand for this service within your locality

2. How do interested clients get in touch with this service?
    Probes:
    - Are they easily accessible within the community?
    - What is the best way for new clients to contact them? What is the most commonly used method of contact?

3. Please describe the m-health services offered?
    Probes:
    - What are the services most requested?
    - What services do you believe are missing?

4. What features are used in the m-health device?
    Probes:
    - What are each of the features required for?
    - Which features are most frequently used and why?
    - Which features do you find the most useful?
    - How do you think these tools benefit the healthcare systems?

Training and Guidelines:

5. How does the service ensure that the information provided is up-to-date?
    Probes:
    - What are the training procedures?

- How is this training facilitated?

6. When a CHW encounters a problem, how and what does she/he do to rectify the problem?
   Probes:
   - Does she/he have a point of contact? Or a support system of any kind?
   - How does she contact them?

Perspectives:

7. Why do you believe this type of service is valuable within the community?
   Probes:
   - What do you think are the primary benefits?
   - How would you recommend this service to other people/friends/family?
   - What would you recommend and why?

8. How do you think this service associates with hospital, clinics, tele-centers or community centers?
   - Is there a channeled system in place that helps direct users where to go if further attention is needed?

9. What are the main potential barriers in effectively providing this service?
   Probes:
   - Do CHWs commonly experience any technical difficulties?

10. What would you recommend for this service in the future?
    Probes:
    - What would you add, what would you change?

Appendix 7: Telephone Script For Participant Contact

Researcher:

Hi my name is Sameen Ahmed, I am a graduate student from McMaster University, completing my Masters in Global Health.

I am contacting you today to ask if you would be willing to participate in a research project exploring the impact of mobile health within urban slum communities in Bangladesh. I will specially be looking at the BRAC's m-health initiative catered to MNCH.

As a participant, I will be asking you to complete a questionnaire and partake in a semi-structured interview surrounding the service. The interview will be digitally recorded and will take approximately 45-60 minutes. Please be assured that there are no risks in carrying out this study, your confidentiality will be maintained, and if you wish to discontinue at any time, there will be no consequences. Furthermore after completion of this study, all documents and files will be disposed.

This study intends to provide preliminary data for future development in m-health technology as well as provide a comprehensive understanding of m-health initiatives within the healthcare systems. This is to ultimately build better health care awareness amongst urban slum communities within Bangladesh.

Please do let me know if you would like to participate within this study and feel free to take you time in your response. I greatly appreciate your time and thank you for taking this call. My contact details are (insert contact details) and I look forward to hearing from you.

Appendix 8: Email/Letter Script For Participant Contact

My name is Sameen Ahmed; I am a graduate student from McMaster University, completing my Masters in Global Health. In writing this letter, I am contacting you to inform you about a study I am conducting on mobile-health within urban slum communities in Dhaka, Bangladesh, specifically an organization under BRAC that focuses on m-health initiatives targeted at MNCH.

I would like to invite you to participate in this study to help me gain an understanding of this organization. As a participant, I will be asking you to complete a questionnaire and partake in a semi-structured interview surrounding the service. The interview will be digitally recorded and will take approximately 45-60 minutes. Please be assured that there are no risks in carrying out this study, your confidentiality will be maintained, and if you wish to discontinue at any time, there will be no consequences. Furthermore after completion of this study, all documents and files will be disposed.

This study intends to provide preliminary data for future development in m-health technology as well as provide a comprehensive understanding of m-health initiatives within the healthcare systems. This is to ultimately build better health care awareness amongst urban slum communities within Bangladesh.

Please do let me know if you would like to be one of the participants within this study, and feel free to take you time in your response. I greatly appreciate your time and look forward to hearing from you. My contact details are listed below.

Sincerely,

Sameen Ahmed

Appendix 9: Demographic Data of Study Sample

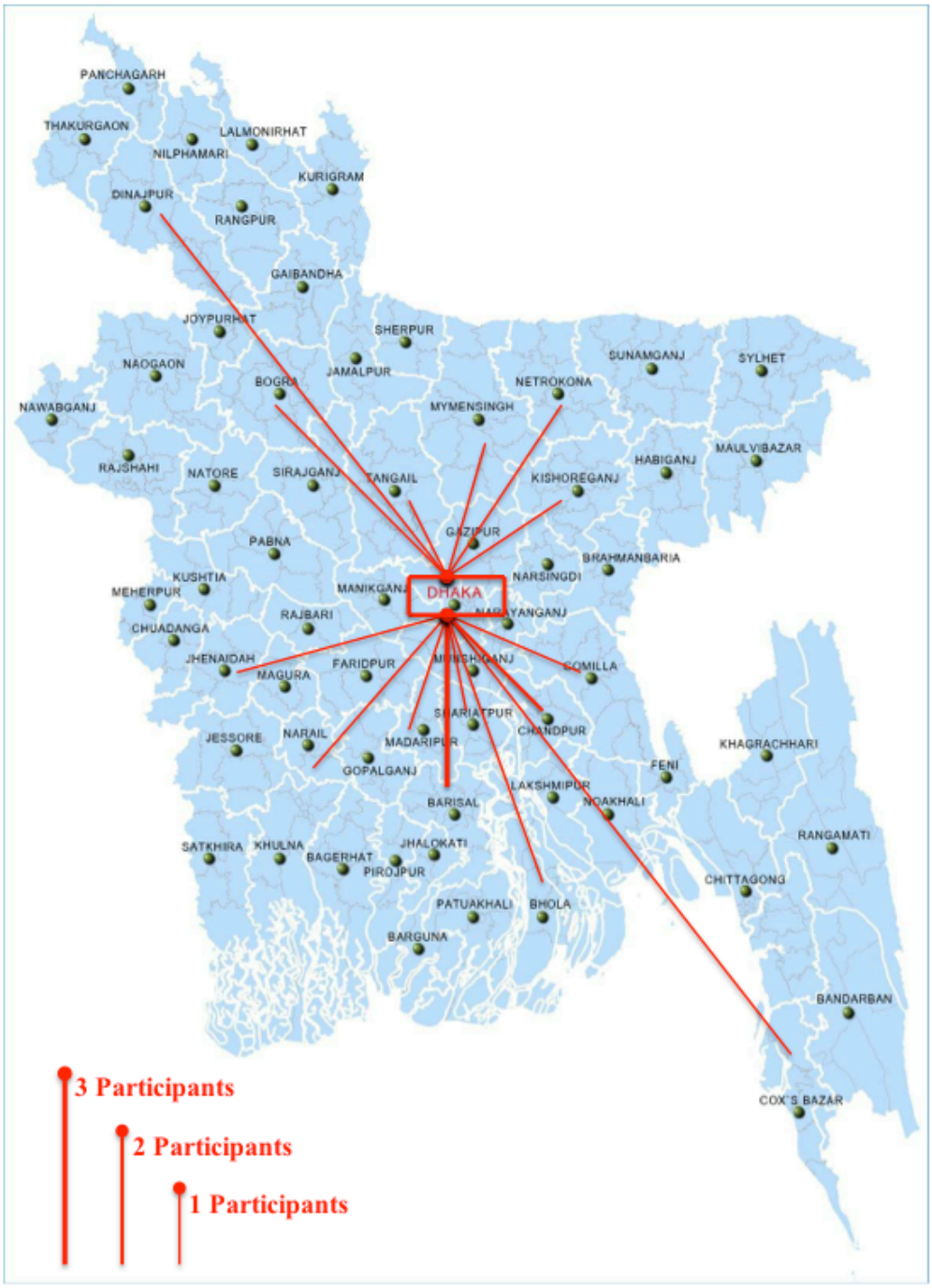

Figure 7: Participant migration from original district to Dhaka

Adapted from Administrative Units of Bangladesh. Retrieved July 22, 2014 from http://www.cegisbd.com/bgd_map.htm

Table 2: Participant's Age Range

Participant	18-25 years n (%)	26-30 years n (%)	31-35 years n (%)	36-40 years n (%)	41-45 years n (%)	Total N (%)
BRAC Developers	0 (0.00%)	3 (42.86%)	2 (28.57%)	1 (14.29%)	1 (14.29%)	7 (100.00%)
CHWs	3 (42.86%)	2 (28.57%)	1 (14.29%)	1 (14.29%)	0 (0.00%)	7 (100.00%)
Villagers	4 (57.14%)	3 (42.86%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	7 (100.00%)
Total	7 (33.33%)	8 (38.10%)	3 (14.29%)	2 (9.52%)	1 (4.76%)	21 (100.00%)

Table 3: Participant's Highest Level of Education

Participant	None n (%)	Primary School Certificate n (%)	Secondary School Certificate n (%)	Higher Secondary School Certificate n (%)	University Degree or Higher n (%)	Total N (%)
BRAC Developers	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	7 (100.00%)	7 (100.00%)
CHWs	0 (0.00%)	0 (0.00%)	5 (71.43%)	2 (28.57%)	0 (0.00%)	7 (100.00%)
Villagers	2 (28.57%)	3 (42.86%)	2 (28.57%)	0 (0.00%)	0 (0.00%)	7 (100.00%)
Total	2 (9.52%)	3 (14.29%)	7 (33.33%)	2 (9.52%)	7 (33.33%)	21 (100.00%)

Table 4: Participant's Gender

Participant	Male n (%)	Female n (%)	Total N (%)
BRAC Developers	4 (57.14%)	3 (42.86%)	7 (100.00%)
CHWs	0 (0.00%)	7 (100.00%)	7 (100.00%)
Villagers	0 (0.00%)	7 (100.00%)	7 (100.00%)
Total	4 (19.05%)	17 (80.95%)	21 (100.00%)

Table 5: Participant's Occupation/Livelihood Type

Participant	Health Services n (%)	Housewife n (%)	Total N (%)
BRAC Developers	7 (100.00%)	0 (0.00%)	7 (100.00%)
CHWs	7 (100.00%)	0 (0.00%)	7 (100.00%)
Villagers	1 (14.29%)	6 (85.71%)	7 (100.00%)
Total	2 (71.43%)	7 (28.57%)	21 (100.00%)

Table 6: Residents Per Household

Participant	1-5 residents n (%)	6-10 residents n (%)	10 or more residents n (%)	Total N (%)
BRAC Developers	7 (100.00%)	0 (0.00%)	0 (0.00%)	7 (100.00%)
CHWs	6 (85.71%)	1 (14.29%)	0 (0.00%)	7 (100.00%)
Villagers	6 (85.71%)	1 (14.29%)	0 (0.00%)	7 (100.00%)
Total	19 (90.48%)	2 (9.52%)	0 (0.00%)	21 (100.00%)

Table 7: Participant's Mobile Ownership

Participant	Yes n (%)	No n (%)	Total N (%)
BRAC Developers	7 (100.00%)	0 (0.00%)	7 (100.00%)
CHWs	7 (100.00%)	0 (0.00%)	7 (100.00%)
Villagers	5 (71.43%)	2 (28.57%)	7 (100.00%)
Total	19 (90.48%)	2 (9.52%)	21 (100.00%)

Table 8: Participant's Closest Hospital

Participant	Combined Military n (%)	Lab-aid Specialized n (%)	Apollo n (%)	Uttara Crescent n (%)	Dhaka Medical n (%)	Ad-din n (%)	Total N (%)
BRAC Developers	1 (14.29%)	1 (14.29%)	1 (14.29%)	1 (14.29%)	3 (42.86%)	0 (0.00%)	7 (100.00%)
CHWs	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	2 (28.57%)	5 (71.43%)	7 (100.00%)
Villagers	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	4 (57.14%)	3 (42.86%)	7 (100.00%)
Total	1 (4.76%)	1 (4.76%)	1 (4.76%)	1 (4.76%)	9 (42.86%)	8 (38.10%)	21 (100.00%)

Table 9: Participant's Distance to Preferred Hospital

Participant	2-3km n (%)	3-4km n (%)	5-6km n (%)	6-7km n (%)	7-8km n (%)	8+ km n (%)	Total N (%)
BRAC Developers	0 (0.00%)	0 (0.00%)	0 (0.00%)	3 (42.86%)	3 (42.86%)	1 (14.29%)	7 (100.00%)
CHWs	6 (85.71%)	0 (0.00%)	1 (14.29%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	7 (100.00%)
Villagers	3 (42.86%)	0 (0.00%)	4 (57.14%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	7 (100.00%)
Total	9 (42.86%)	0 (0.00%)	5 (23.81%)	3 (14.29%)	3 (14.29%)	1 (4.76%)	21 (100.00%)

Table 10: Villagers Closest Community Center

Participant	Branch Center n (%)	Delivery Center n (%)	Total N (%)
Villagers	2 (28.57%)	5 (71.43%)	7 (100.00%)

Table 11: Villager's Distance to Closest Community Center

Participant	0.1-0.2km n (%)	0.2-0.3km n (%)	0.3-0.4km n (%)	0.4-0.5km n (%)	0.5-0.6 km n (%)	0.6-0.7 km n (%)	Total N (%)
Villagers	0 (0.00%)	3 (42.86%)	0 (0.00%)	3 (42.86%)	0 (0.00%)	1 (14.29%)	7 (100.00%)