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EVALUATING THE USE OF MOBILE PHONE TECHNOLOGY TO ENHANCE POSTNATAL CARE IN SOUTH AFRICA

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EVALUATING THE USE OF MOBILE PHONE TECHNOLOGY TO ENHANCE POSTNATAL CARE IN SOUTH AFRICA

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Maternal and child care in South Africa is sub-optimal, contributing to the maternal mortality and high infant mortality rates in the country. About a third of these deaths are due to modifiable factors, some of which are related to poor communication between healthcare providers and patients. A potential intervention that could reduce some of these modifiable factors is the incorporation of mobile phone technology.

The goal of this study was to determine the feasibility and effectiveness of incorporating mobile phone technology in postnatal care. The specific objectives were: to determine patterns and preferences of cell phone use among mothers; to determine healthcare staff attitudes towards the use of mobile phone technology in postnatal care; to determine whether a mobile phone intervention using SMS and phone call reminders will increase rates of attendance in postnatal clinics; to determine the cost-effectiveness of these reminders; and to determine the patients' satisfaction with their reminders.

The study was divided into 3 sub-projects. (i) In sub-project A, cross-sectional questionnaires were used to determine patterns and preferences of mobile phone use among mothers. (ii) In sub-project B, cross-sectional questionnaires were used to determine staff attitudes regarding use of mobile phones to enhance communication. (iii)

In sub-project C, a randomized controlled trial (RCT) was carried out to determine the impact of a mobile phone intervention on rates of postnatal clinic attendance.

(i) 375 mothers participated in sub-project A. Of these, 98% had access to a mobile phone, and 83% owned personal mobile phones. 86% of the mothers had positive attitudes towards the use of mobile phones for patient: provider communication. (ii) 135 healthcare workers participated in sub-project B. Of these, 75% reported willingness to use a mobile phone to communicate with patients. (iii) In the RCT involving 415 mothers, the use of phone call/SMS reminder significantly increased rates of patient attendance at their 3-day appointment from 45% in controls to 72% and 81% in mothers who received phone calls and SMS reminders, respectively ($p < 0.001$). SMS reminders were more cost-effective than phone calls. 94% of mothers who got reminders were satisfied with them.

Mobile phone technology can effectively be used to enhance communication between healthcare providers and patients in South Africa due to its high reach and acceptability among patients and healthcare staff. Additionally, mobile phone technology is simple to use and cost-effective. Mobile phone technology may effectively be used not only for appointment reminders, but also in other areas such as health education/awareness, chronic disease management, and HIV medication monitoring and compliance.

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1. INTRODUCTION:

Overview:

The goals of the introduction are three-fold:

1) To provide an overview of Maternal and Child Healthcare in South Africa, with an emphasis on the leading causes of deaths in infants, children under five, and mothers in the country.

2) To briefly describe postnatal care in South Africa, highlighting the potential of reducing unnecessary infant and maternal mortality in the country through the provision of robust postnatal healthcare.

3) To describe the use of mobile phone technology in healthcare. Mobile phone technology has the potential of significantly improving maternal and child healthcare in South Africa and thereby reducing some of the preventable causes of deaths in the country.

The information in this introduction in presented under the following sub-titles:

- 1.1: Maternal and Child Care in South Africa
- 1.2: Postnatal Care in South Africa
- 1.3: Mobile Phone Technology and Healthcare
- 1.4: Mobile Phone Technology in South Africa

1.1: Maternal and Child Care in South Africa:

South Africa is the wealthiest country in Africa, with a GDP (purchasing power parity) of US$ 488.6 billion, making it the 26th wealthiest nation in the world in 2009.[10] Despite its wealth, South Africa's healthcare is deficient, especially for a country with such vast resources.

Map of South Africa, showing major cities and neighboring countries

The infant mortality rate (IMR) in South Africa in 2009 was estimated at about 44.4 deaths per 1,000 live births; slightly higher than the global infant mortality rate of 44.1 deaths per 1,000 live births.[10] South Africa has the 62nd highest infant mortality rate (IMR) in the world.* It fares better than most other Sub-Saharan African countries except Botswana, Eritrea, and Zimbabwe, which all have lower reported infant mortality rates despite having significantly less resources than South Africa.[10] †

HIV/AIDS is linked to the high infant mortality rates in South Africa.[9] It is estimated that 60% of deaths in children under-five years of age in the country occur in

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* The country with the highest IMR in the world is Angola, with 180.21 deaths/ 100,000 live births. The country with the lowest IMR is Singapore, with 2.31 deaths/100,000 live births. In the U.S., the IMR is 6.22 deaths/100,000 live births.

† Note it is likely that the numbers reported by the CIA World Factbook are under-estimates. In the Saving Babies 2003-2005 report in South Africa, the IMR was reported as 95 deaths per 100,000 live births, while the CIA World Factbook reported a much lower figure for that year. However, for consistency in comparing country data around the world, the 2010 CIA World Factbook has been referenced in this thesis.

HIV-positive children.[33,52] In 2009, the prevalence of HIV in South Africa was estimated as 18.1%, with the bulk of HIV positive people being adults of reproductive age.[10] Children in South Africa also have high HIV rates; unfortunately, most of these do not make it past their fifth birthday or even into adulthood.[9]

In 2001, the South African "Children Healthcare Problem Identification Programme" (CHIP) and the "Perinatal Problem Idenfication Progam" (PPIP) were established to conduct audits to determine the causes of deaths in children under five years of age, and in neonates respectively. These programs not only sought to identify primary causes of death; but they also sought to determine what modifiable factors at various levels of care contributed to these deaths.

The CHIP audit over a two-year period between 2003 and 2005 revealed that the most common direct causes of death in children under 5 years in South Africa were: lower respiratory tract infections (33%), gastroenteritis (15%), and septicemia (12%).[9, 72] Sixty percent of all the total deaths were HIV-related; and 60% of all the total deaths also occurred within the first year of the children's lives. 70% of deaths occurred in underweight children. The audit also found that administrative modifiable factors were present in 31% of the childhood deaths in South Africa. [52] These administrative factors included: inadequate facilities, insufficiently trained healthcare workers, transportation problems, and other factors. Healthcare staff-related factors such as poor assessment, monitoring, and management of patients by healthcare workers (due to insufficient knowledge, inadequate training/insufficient skills, lack of time to adequately address patient needs, and lack of resources) also contributed to these deaths.[57]

After concluding their studies, CHIP had several recommendations, some of which are as follows. (1) That increased efforts need to be taken to ensure that programs aimed at preventing mother-to-child transmission of HIV (PMTCT programs) function efficiently, thereby reducing HIV infection in children and subsequently the IMR. (2) That increased efforts need to be undertaken to address malnutrition in children. (3) That there should be better training of existing healthcare staff to increase their skills and knowledge, for example by implementing more robust continuous health education measures. (4) That more pediatric staff should be trained in the country. (5) Finally, they recommended more accurate data collection and storage methods to reduce errors in patient care caused by improper documentation of patient health data.[52]

The Perinatal Problem Identification Progam (PPIP) audit of 2005-2007 focused mainly on perinatal deaths. They found that the most common causes of deaths in neonates in South Africa were: immaturity-related deaths; hypoxia; infections; and congenital abnormalities. Their analysis of probable preventable causes of death found that 43% of neonatal deaths within the country in that two-year period were preventable. The most common modifiable factors contributing to those deaths included: (1) Patient factors such as: delay in seeking medical attention, lack of antenatal care or booking of antenatal care in late stages of pregnancy, and infrequency of antenatal care. (2) Medical staff related factors such as poor clinical decisions made by inadequate assessment, monitoring and management of patients. (3) Administrative factors such as: inadequate facilities; poor transportation (e.g. of patients from a community healthcare center to a secondary or tertiary center for more advanced care); insufficient skilled staff. PPIP's

recommendations were similar to CHIP recommendations emphasizing improved quality of antenatal and postnatal care to reduce preventable deaths.[9,52,72]

Mothers:

The maternal mortality rate (MMR) in South Africa is estimated to be between 170 – 400 deaths per 100,000 women.[72,83] This is an extremely high maternal mortality rate for a country with its resources. HIV/AIDS has contributed significantly to South Africa's high maternal mortality rate; and is thought to be directly responsible for about 43.7% of maternal deaths in the country.[53] For example, HIV-negative mothers in South Africa have a MMR of 34 deaths per 100,000 live births (similar to statistics in Thailand and Brazil); whereas HIV-positive mothers have a tenfold increase in mortality rates.[10,53]

Aside from HIV/AIDS, other top causes of deaths in the country include: (2) Hypertension complications – responsible for 15.7% of maternal deaths; (3) Obstetric hemorrhage (antepartum and postpartum) – responsible for 12.4% of deaths; (4) Sepsis – responsible for 9% of deaths; and (5) Pre-existing maternal conditions (especially in mothers over 35 years) – responsible for 6% of deaths. It was noted that women under 20 years of age had an increased risk of death from hypertensive complications; while in mothers over 35 years, hemorrhage, ectopic pregnancies, embolism and pre-existing conditions are the leading cause of death.[53]

According to the Saving Mothers 2005-2007 report in South Africa, 38.4% of maternal deaths are avoidable.[53] These avoidable deaths are caused by very similar factors as those contributing to infant and child deaths. Again, these include: administrative/ systemic factors such as poor transportation, lack of adequate healthcare

facilities, lack of appropriately trained staff; patient-oriented factors such as: non-attendance at clinics (antenatal and postnatal care), delayed attendance to clinic/hospital; and staff-oriented factors in management errors. [53] Most of the maternal deaths commonly occur in the postpartum period (45.4% of cases) compared to 9% of deaths in early in pregnancy, 36.7% in the antepartum and 8.7% in the intrapartum period. [47] Because the vast majority of maternal deaths occur in the postpartum period, postnatal care in South Africa needs to be made more robust to detect and treat mothers with complications such as hemorrhage or infection thereby preventing unnecessary deaths. [46]

Healthcare Structure in South Africa:

Part of the reason why South Africa has such adverse health outcomes, despite its wealth, is the two-tier healthcare structure in the country. About 82% of the South African population is served by the public sector; while 18% of South Africans, mostly middle- and high-income earners, are members of medical schemes that allow them access to private sector healthcare. [70] Healthcare provided in South Africa's private sector is advanced, and equivalent in quality to healthcare provided in the western world.‡ There are great disparities between the two tiers of healthcare in South Africa. For example, most of the nation's physicians – both primary care physicians and specialists – serve the private sector. A vast majority of other healthcare professionals such as pharmacists mostly serve the private sector. [70] Nurses dominate care provided in the public sector in South Africa, and they work hand-in-hand with a few physicians (mostly faculty of

‡ In fact, many foreigners from Europe/ elsewhere in Africa/ Asia, etc looking for top quality medical/surgical services travel to South Africa for quality private healthcare at relatively affordable prices.

medical schools and residents/ physicians-in-training) to deliver care to the vast majority of South African citizens.[17,70]

In addition to disparities among healthcare workers, there are also huge disparities in health expenditures between the private sector and public sector. The South African state contributes to 40% of all the total health expenditures in the country; yet, there is a great disparity in the allocation of state funds in healthcare between the two different groups. It is estimated that R59.36 (equivalent to US $7.42) was spent on drugs per person in the public sector, while R800.29 (equivalent to US $100) was spent on drugs per person in the private sector.[§] Based on this unequal allocation of healthcare resources, it is no wonder that there is a vast disparity between healthcare outcomes of the majority of the population that is served by the public sector, versus about a fifth of the population that receives quality private healthcare.[70]

Public sector healthcare in South Africa is stratified in four levels. The most basic primary care (level 1 care) is provided in local authority clinics. There have been attempts to spread out local authority clinics evenly throughout South Africa, to enable people easier access to these health centers. Most mothers in South Africa receive their antenatal and postnatal care in local authority clinics, although deliveries are typically not carried out there.[57] More comprehensive basic healthcare in the South African public health sector is carried out in Community health centers (CHCs). They are level 1 centers mostly served by nurses and a few supervising physicians, and offer a broader range of services to people such as psychiatric care. Simple deliveries are usually carried out by

[§] To convert currencies, the average exchange rate for the year 2009 was used as follows: 8 South African rands = 1 U.S. dollar (ZAR 8 = USD 1).

midwives in community health centers, while more high-risk pregnancies are referred to level 2 centers.

Level 2 healthcare centers in South Africa are mainly district hospitals. They are better staffed by physicians and typically have more resources than community health centers or local authority clinics. Complicated cases are referred from level one centers to district hospitals. Deliveries by Caesarian Section are carried out in district hospitals, which have operating rooms and facilities such as ICUs for babies born in distress. Tertiary (level 3) care in South Africa is carried out in regional, provincial, and national hospitals. These centers have more physicians; specialists; and more advanced equipment to provide better care to sicker patients in the public sector.[47,57,70]

This paper focuses on healthcare provided by the public sector in South Africa, which is stretched thin due to limited resources (financial, healthcare staff, facilities, and so on). The problems reported above from the Medical Research Council (MRC) Unit for Maternal and Infant Health Care Strategies are based on research carried out in public sector hospitals and community healthcare centers, and therefore do not reflect challenges faced by the segment of the population served by the private healthcare sector.

1.2: Postnatal Care in South Africa:

Postnatal care is the healthcare provided to mothers and their newborn babies after delivery and, in South Africa, it is provided within 1 week (ideally at 3 days: the "3-day visit") and at 6 weeks post delivery in the public sector.[47] Most mothers and babies in South Africa receive their postnatal care in community health centers and local authority clinics (the same primary healthcare sites where they receive their antenatal care). Mothers and babies with advanced conditions – such as several co-morbidities in mothers or congenital abnormalities in children – receive postnatal care at secondary referral centers such as district hospitals.[47,57]

Postnatal care is essential, as it enables early identification and treatment of complications that may have arisen during the antenatal, intrapartum, and postpartum period – such as hypertension, infection, bleeding, depression and breast problems in the mother; and infection, jaundice, anemia, and feeding difficulties in the neonate.[46,47] It is estimated that fewer than 50% of mothers and babies in South Africa receive adequate postnatal care, especially within 1 week, during the 3-day visit.[52,53] It is also estimated that at least 30% of newborn deaths in South Africa could be averted if at least 90% of mothers and babies received essential interventions early, underscoring the importance of the 3-day postnatal clinic visit to screen for and to treat these complications.[47,53]

In addition to enabling early detection of acute and life-threatening conditions in mothers and infants, postnatal care also enables the mothers to obtain counseling and information on infant feeding and nutrition, hygiene, family planning, danger signs in the mother/baby, and other related issues; allowing them to better care for themselves and

their babies.[46,47] As shown by CHIP data, 70% of children under five years of age who perished in South Africa were underweight.[52] While several factors contributed to the malnourishment and subsequent demise of these children (such as economic reasons), essential counseling and guidance on nutrition could avert malnutrition caused by inadequate knowledge on proper feeding of babies.

Postnatal care is extremely important for HIV positive mothers and their infants as a continuation of the Prevention of Mother to Child Transmission of HIV (PMTCT) program.[15,57] Prior to the birth of the baby, these PMTCT steps are carried out: HIV testing of the pregnant mother; CD4 count if the mother tests positive for HIV; initiation of HAART if the mother's CD4 count is low; counseling of the mother on safe infant feeding and future family planning; and ARV prophylaxis at birth. Many steps of PMTCT are also carried out at postnatal clinics: during the 3-day postnatal visit, HIV positive mothers are able to receive additional counseling on safe infant feeding, family planning, safe sex and other HIV-related concerns. Mothers who have not been tested for HIV may also receive testing and counseling during that first postnatal visit.[15,46,47]

During the 6-week postnatal clinic visit, HIV-positive mothers get their CD4 counts rechecked to determine whether they should receive HAART and children of HIV-positive mothers also get PCR tests at their 6-week postnatal visit in order to determine their status early. Those children who test positive are referred to pediatric HIV programs and benefit from early initiation of treatments such as ARV therapy and prophylactic Cotrimoxazole – an antibiotic that reduces rates of Pneumocystis carinnii pneumonia (PCP) and other potentially lethal infections in HIV-positive children.[46,47]

Postnatal care is extremely important in South Africa, given that postpartum complications are a major cause of maternal morbidity and mortality; and also given the high prevalence of HIV in the country and the need for rigorous implementation of PMTCT. [53,67] Yet, postnatal care is not delivered optimally in South Africa. Many gaps and deficiencies exist in its delivery. For example, although there are national postnatal guidelines defining procedures and standards of postnatal care, these guidelines are not properly understood and adhered to by healthcare workers.[35] There is also little documentation of postnatal care and poor transmission of health information and records between the various health centers involved in the infant and mothers care.[62] Further, there is little understanding of the choices women make regarding follow up for themselves and their infants and factors influencing their choices.

These, and many other gaps, underscore the need for research to be carried out to further understand the deficiencies in postnatal care, the contributing factors and interventions that can be carried out to improve postnatal care. Several interventions have already been proposed to improve aspects of postnatal care in the country. For example, the MRC Unit for Maternal and Infant Health Care Strategies based at the University of Pretoria have developed an "Essential Postnatal Care" training manual and syllabus, aimed at equipping nurses with the knowledge and skills to better detect and manage postpartum complications in mothers and babies.[46,47] Additionally, they developed the postnatal card in 2007, designed to improve postnatal care by: enhancing communication between hospitals where deliveries are carried out and clinics where mothers and infants receive postnatal care; providing a checklist of essential questions to ask and procedures to perform; increasing uptake of postnatal services by mothers by serving as a reminder

for mothers to attend their 3-day and 6-week visits with their babies; and acting as an additional patient data record that can be used for research purposes.[47,62] Based on the successes of the postnatal card, a more comprehensive "Health Book" is being developed by the South African department of health; which will enable information about the pregnancy from the first antenatal visit to the last postnatal visit to be recorded in one central location.[45]

While these initiatives promise to improve postnatal care in South Africa, more research needs to be carried out to identify additional interventions that are cost-effective and will further improve postnatal care in the country. A suggested intervention is the incorporation of mobile phone technology in postnatal care in the country. Given the ubiquity of cell phones in South Africa, it is likely that the technology can be utilized in several ways. It may be used to improve communication among healthcare providers, and also to enhance communication between providers and patients.[34] The technology may also be utilized for patient education. It may also be used for data collection, for research and quality improvement purposes; and many other ways. To date, there is no documentation on the use of mobile phone technology in antenatal or postnatal care in South Africa. There is also no documentation on mobile phone use among the populations served in the public sector, and their patterns and preferences of mobile phone use. Finally, there is no documentation on views of healthcare staff in South Africa regarding the incorporation of new technologies such as mobile phone technology to enhance healthcare delivery – underscoring the great need of research to obtain this information.

1.3: Mobile Phone Technology and Healthcare

Information and Communication Technologies (ICTs) are a range of technologies for gathering, storing, retrieving, processing, analyzing and transmitting information and include the internet, computers, mobile phones, smart phones, and personal digital assistants (PDAs), and many more.[73] ICTs have drastically changed the way in which the world communicates and enhanced globalization. They have impacted the world in several aspects: economically (for example through job creation, and through generation of economic growth by enabling the shift from industrial economies to knowledge economies); socially (in sectors such as healthcare, environmental conservation, human rights, etc) and politically.[3,74]

Within ICTs, the fastest growing segment is the use of mobile phone devices (m-technology) such as simple mobile/cell phones, smart phones, personal digital assistants, and global positioning system (GPS) devices. m-Technology began in 1985, when the Global System for Mobile Communications (GSM) was established by several companies.[3,73] By 1997, the GSM Association had connected one billion people around the world and 30 months later, two billion people had access to mobile phone technology. It is now estimated that global mobile phone usage now exceeds 3.5 billion people, with 80% of the world's population now living in areas with mobile phone coverage.[3] Of these, over 64% of users live in the developing world.[73] By 2012, it is estimated that over 85% of the world's population will reside in an area with mobile phone coverage, and that 50% of all individuals in the remote areas of the world will have mobile phones. Africa has the highest rate of new uptake of cell phones around the world, and much of

the projected increase in the uptake of m-technology is expected to come from the sub-continent.[3,73]

Mobile phones in healthcare:

mHealth is the incorporation of mobile phone technologies in healthcare. These technologies include voice messaging, text messaging (SMS), multi-media messaging, mobile phone data collection and information retrieval.[74] mHealth has great potential in addressing pressing healthcare and health system issues, given the ubiquity of mobile phones around the world and the advantages of mobile phone technology including its high reach, cost-effectiveness, and relative simplicity to use, especially in carrying out basic functions such as voice and text messaging.[8,34,73,75]

mHealth is now extensively used in healthcare in such areas as: (1) Health education and awareness, (2) Preventative care and chronic disease management, (3) Data collection and health record access, (4) Monitoring /medication compliance, (5) Disease/emergency tracking, (6) Administrative systems, (7) Health information access, and (8) Medical analysis, diagnosis and consultation.[5,75,76] A vast majority of mHealth initiatives are developed and conducted in the developed world. Examples of the few mHealth initiatives in the developing world are listed below, classified under the functions for which they are utilized.[8,75]

1) Health education and Awareness: mHealth has been utilized to educate both healthcare workers and patients in several developing countries around the world. For example, in Guatemala, mobile phones have been used to train nurses in rural areas through "Telenursing," in which community nurses are trained by real-time

teleconferencing on their cell phones.[75] In India, Uganda, Tanzania, Kenya, Malawi, Mozambique, and Namibia, the general public has access to free HIV/AIDS information through the "Freedom-from-HIV/AIDS" program. It is a software product developed for use on cell-phone as an innovative game that educates players on HIV/AIDS as they play games that are available the limited editions as software that can freely be downloaded to mobile phones. [75,76] In South Africa, mobile phone software such as MXit is also available for download. Through MXit, health education on HIV/AIDS issues and other general health information is delivered to users of the service (mostly teenagers and young adults).[75]

(2) Preventative care and chronic disease management: While mHealth is extensively used for chronic disease management such as diabetes care in the developed world; in the developing world it is mainly used to manage HIV/AIDS care in patients. Examples of such initiatives include the "TRACnet HIV/AIDS Solution" in Rwanda. This system is used to collect, store, retrieve, and disseminate critical program, drug, and patient information related to HIV/AIDS care and treatment of public sector patients in the country using mobile phones.[75]

3) Data collection and health record access: Mobile phone technology can be used very effectively in data collection. For example, in Botswana, the AED-SATELLIFE program is used by healthcare workers to enter patient information electronically through PDAs that transmit the patient records to a centralized server and workers are then able to retrieve old patient records on their PDAs in the field. [75,7] In a remote part of Peru, the company Voxiva developed an electronic patient record system in which information was collected via mobile phones. This electronic record system

through mobile phones/PDAs has been very useful in patient monitoring, patient referrals to regional health centers, follow-up care of mothers, supply tracking, and disease surveillance.[79]

In research, mobile phone technology can be used for data collection with the aid of several software programs such as EpiHandy and EpiSurveyor – products that allows users to create surveys and carry out quick and efficient data collection on mobile phones, eliminating bulky questionnaires and costs/errors associated with manual data entry. These programs were specifically developed for Africa to be used on PDAs and pocket PCs. They have successfully been used in countries such as Burkina Faso, Kenya, and Zambia; where healthcare workers used their PDAs/smartphones to collect data about measles from clinics and other sites around their country in a World Health Organization (WHO) launch against measles campaign.[22] The technology is being adapted to collect vital health information to fight against diseases e.g. malaria; and plans are underway to spread it to 20 other African countries, given its successes in these three countries.[22,75]

4) Monitoring /medication compliance: In the Western Cape province of South Africa, a non-governmental organization called Cell-Life uses mobile phone technology to better manage care for HIV positive patients. Cell-Life has implemented a large data and information management system that has enabled some healthcare records for patients from three academic, eight regional, and twenty two district hospitals to be electronically stored. Although they have been successful with major hospitals, they are still yet to expand their reach to community health centers and local authority centers (which at present do not have the technological capacity to deliver these services). Cell-

Life has been successful in projects in the Western Cape that include the use of mobile devices for patient records. Healthcare staff (mostly home-based care givers) enter patients' data in the field into their electronic databases through mobile phones and also use mobile phones to book patients for HIV voluntary counseling and training (VCT) sessions in real time; thereby increasing the efficiency of the services delivered.[58,59]

In Brazil, the Virtual Health Pet program is used in the private sector to remind patients to take their required medications on time. A similar program called SimPILL is also utilized in the private sector in South Africa to remind patients to take their medications on time and to track their adherence.[75]

5) Disease/emergency tracking: Mobile phones may be used for disease surveillance and emergency tracking. For example, in South East Asia after the 2004 tsunami, the "Tami Nadu Health Watch" program was created to communicate information about disease outbreaks in real-time.[80] Peru has a similar surveillance system, and in Ghana, PDAs are also used by public health officials to track areas of measles outbreaks in the country.[75] In Mozambique, the "Healthnet system" – which uses GPS and mobile phone systems – has been implemented for malaria control mapping and tracking.[2] In Madagascar, a sentinel system has also been developed to monitor outbreaks such as dengue fever.[60]

6) Administrative systems: Within the private sector in countries such as South Africa, mobile phone technology has been implemented to enable more accurate and efficient patient-billing.[75]

(7) Health information Access: PDAs are now commonly used by some physicians in Uganda, Kenya, Ghana, Nigeria, Botswana, South Africa and many other developing countries to enable physicians to access updated health information to help improve management of patients. Most of these devices are individually owned by physicians, although in a few countries such as Botswana and Uganda, they are supplied by the government.[75]

8) Medical analysis, diagnosis and consultation: In Uganda, mobile "Walkie Talkies" were implemented by the government to enable a network of traditional birth attendants in Uganda to partner with the public health service centers to obtain medical analysis, diagnosis, and consultation for the pregnant women in their communities. The communication system has enabled increased and timelier referrals of patients with complications to more advanced healthcare systems, leading to the reduction of maternal mortality rates in the country. [1] In Argentina, the Digital Inclusion Kit is used by healthcare workers to transmit patient data such as blood pressures, EKGs, histories, etc to physicians for assistance with diagnosis and consultation. In India, the TeleDoc system is utilized by field workers to examine patients and transmit findings using mobile devices to healthcare workers who then provide feedback on management.[75]

Of note, most of the systems described above are large-scale implementations of mobile phone technologies requiring significant financial input from government sectors, non-governmental organizations, and private firms. While most of them are reported to be very effective systems, few of them have undergone rigorous, scientific studies to highlight their effectiveness.

There have been a few small-scale studies showing simpler and more cost-effective ways to improve healthcare using mobile phone technologies. Most of these small-scale studies have been carried out in the developed world.[39] In September 2008 and in February 2009, a literature review was carried out on PUBMED to determine areas in which mobile phones have been implemented simply to improve healthcare outcomes. A pubmed search was carried out using these search words: "mobile", "cell", "phone" and "health." A total of 766 articles were generated from these search; 77 of which described simple application of mobile phones to improve healthcare outcomes and process measures (for example, to increase rates of attendance to clinic; or to increase adherence to medication regimens). Only 11 of the 77 studies on mHealth were conducted in the developing world. These included studies in Thailand and Brazil, in which SMS reminders were used to increased rates of attendance in primary care clinics;[14,41] and a study in Korea in which motivational text messages were used to influence behavioral change, leading to increased weight loss in a group of dieting patients.[33] There remains a great need for more studies to be carried out in developing countries to demonstrate simple ways in which mobile phone technologies can be used to improve healthcare outcomes and process measures.[3, 8]

1.4: Mobile Phone in South Africa

Mobile phones in South Africa are used extensively in personal lives and business transactions. In the country, there are approximately 36 million active mobile phone users, and around 80% of all youth and adults have a personal mobile phone.[58,74] Mobile

phones have impacted people's lives in SA tremendously: a study by Vodafone on the socio-economic impact of cell phones found that 78.7% of rural respondents said it improved their relationships, 77.4% said they would rather call than travel to visit family members, 26.5% said they were useful in emergencies, and 76% used them to follow up on social welfare, water, sanitation and electricity applications or income-generating opportunities.[74] Most South Africans value mobile phones highly. Another study conducted by researchers at the University of Witwatersrand found that most respondents valued mobile phones so much that they would make sacrifices to ensure they had money to buy credit. For example, many reported that they would rather substitute cell phone credit for purchase of clothes, accessories, or even food sometimes – for example skipping lunch to buy airtime. [23] In terms of connectivity, 96 percent of people in South Africa live in area with cell phone coverage.[74]

Given its ubiquity in South Africa, mobile phone technology has great potential in improving healthcare outcomes in the country. There are currently no studies or reports of the use of mHealth in antenatal or postnatal care in the country. Additionally, it is unknown how common mobile phone use is among patients seeking antenatal/postnatal care in the public sector of the country, and their patterns and preferences of mobile phone use. It is also not known how acceptable it is to healthcare staff and patients to incorporate mHealth to antenatal and postnatal care. Finally, it is unknown whether it is necessary to actually speak to individuals when incorporating mobile phone technology to healthcare, or whether text messages (SMS'es) might be just as efficacious as phone calls.

2. STATEMENT OF PURPOSE:

2.1 AIM: The aim of this project is to evaluate the utility of mobile phone technology in enhancing postnatal care in South Africa.

2.2: SPECIFIC OBJECTIVES:

To evaluate the utility of mobile phone technology in enhancing postnatal care in South Africa by conducting 3 sub-projects with the following objectives:

1) Sub-project A:

- To determine the patterns and preferences of mobile phone use among mothers receiving antenatal care in three South African provinces: Gauteng, Mpumalanga and Limpopo.

2) Sub–project B:

- To determine healthcare provider attitudes towards mHealth.

3) Sub–project C:

- To carry out a randomized controlled trial to determine the impact of mobile phone intervention (sending mothers reminders via text messaging and voice messaging) on rates of attendance at postnatal clinics within a week of delivery.
    - To determine how satisfied patients were with the mobile phone reminders.
    - To determine which means of communication is more cost-effective.

2.3: HYPOTHESES:

A) Sub-project A:

This is a descriptive study to determine patterns and preferences of phone use among mothers receiving public sector postnatal care in Gauteng, Mpumalanga, and Limpopo provinces in South Africa. In addition to describing their patterns and preferences of mobile phone use, these hypotheses will be tested:

- Higher socio-economic status (employment, higher education level) is associated with greater use of mobile phones among mothers in South Africa.
- Use of mobile phone technology to enhance postnatal care is acceptable among patients.

B) Sub-project B:

- Most healthcare staff in South Africa have positive attitudes regarding incorporation of mobile phone technology in healthcare.

C) Sub-project C:

- A mobile phone intervention using phone calls and text messages will improve rates of attendance at postnatal clinics in South Africa
- Phone calls and text message appointment reminders are highly acceptable among patients in South Africa

2.4: RESEARCH QUESTIONS:

A) Sub-project A:

- 1: What are the baseline characteristics of mothers receiving care in public sector clinics in parts of Gauteng, Mpumalanga, and Limpopo (in terms of age, education level, employment, etc)?
- 2: What percentage of mothers have access to landline and mobile phones?

  -Of these, how many have personal mobile phones?
- 3: What functions do mothers use mobile phones for? (Calling, texting, multi-media messaging, etc)

  -Do factors such as age, education level, and location affect their use of phones?
- 4: How frequently do these mothers use their mobile phones?
- 5: Have patients ever been contacted by healthcare staff on their mobile phones?

  -If yes, for what?
- 6: Are patients willing to be contacted on their phones by healthcare workers?
- 7: If yes, what mode of communication (SMS/call) would they prefer?
- 8: What types of information would they like these healthcare workers to communicate to them when they are contacted?
- 9: What are the best times to reach patients?
- 10: What are the patients' preferred languages of communication?

B) Sub-project B:

- 1: What are the baseline characteristics of healthcare workers regarding their access to mobile phones and their use of mobile phones?
- 2: What communication methods do they currently use to reach patients receiving antenatal/postnatal care?
- 3: Do they feel these communication methods are effective?
- 4: What do healthcare workers perceive as barriers to effective communication with patients?
- 5: Do healthcare workers feel it is acceptable to communicate the types of information listed below via text messaging or calling patients on their mobile phones? (test results, appointment reminders, medication reminders, and health education information)
- 6: Are healthcare workers willing to use mobile phones to enhance their current communication methods with patients?
- 7: Do healthcare workers feel that mobile phone technology is cost-effective?
- 8: Do healthcare workers feel like mobile phone technology is time-saving?
- 9: Do healthcare workers feel that mobile phone technology will improve patient outcomes?
- 10: Do healthcare workers feel that mobile phone technology could enhance the overall quality of care and services that patients receive?

C) Sub-project C:

- 1: What are the baseline characteristics of mothers enrolled in the RCT?
- 2: What are their patterns and preferences of mobile phone use?

  In terms of: -Level of access to phones

  -Functions used on phones

  -Frequency of mobile phone use

  -Willingness to contacted by healthcare providers

  -Preferred mode of contact

  -Preferred language

- 3: Can a mobile phone intervention –which involves sending mothers reminders via text messaging and voice messaging – increase rates of attendance at postnatal clinics within a week of delivery (3-day postnatal visit)?

  (The primary hypothesis of this sub-project)

- 4: What are the reasons for non-attendance at clinics?
- 5: What complications were detected at clinic during the 3-day visits?
- 6: How satisfactory are mobile phone reminders to mothers?
- 7: Which type of mobile phone reminder is more cost-effective: phone calls or text messaging?

3. METHODS:

3.1) OVERVIEW:

As mentioned in the Statement of Purpose, this study was divided into three sub-projects, which used the methods listed below. IRB approval for the study was obtained from the HIC committees at Yale University School of Medicine as well as the University of Pretoria Medical School.

A) Sub-Project A:

Cross-sectional questionnaires and interviews to determine patterns and preferences of mobile phone use among patients seeking care in government hospitals in three different regions in South Africa: Tshwane district of Gauteng Province; Limpopo province, and Mpumalanga province.

B) Sub-Project B:

Cross-sectional questionnaires and interviews among healthcare staff to determine their attitudes towards the incorporation of mobile phone technology in healthcare.

C) Sub-Project C:

A randomized controlled trial to evaluate the effectiveness of mobile phone reminders on attendance rates at postnatal clinics in South Africa

- Follow up surveys to determine their satisfaction with the reminders

Specific details on methods used will be described according to the sub-project in Section 3.3. Details about the data analysis are described in Section 3.4.

3.2) SETTING/ STUDY SITES:

The project was carried out in three provinces:

- Gauteng
- Mpumalanga and
- Limpopo.

Figure 2: Map of South Africa's provinces

1) Gauteng

Gauteng is the smallest province in South Africa, with only 1.4% of the land area. It is also one of the wealthiest and most urbanized provinces in the countries, and is home to two major cities in South Africa: Johannesburg and Pretoria/Tshwane. It is the most populous province of South Africa with over 10.5 million people. Gauteng is divided into 3 metropolitan municipalities, and 3 district municipalities.[68]

In Gauteng, all three sub-projects were carried out in the City of Tshwane Metropolitan municipality. Within Tshwane municipality, it was carried out in Mamelodi township, on the northeast outskirts of Tshwane/Pretoria Metropole. Mamelodi is one of the former black townships that was established during the apartheid era in South Africa; and currently has a population of close to one million people. Like many of the former

black townships in South Africa, Mamelodi is plagued with problems such as extreme poverty, poor housing, high unemployment, inadequate education, and many other socio-economic problems that may take years to eradicate despite efforts by the new South African government to improve sanitation, housing, education and economic empowerment in townships.

Mamelodi is served by two public health centers in which deliveries are carried out: Stanza Bopape Community Health Center and Mamelodi Hospital (a district hospital). It is also served by the following local authority clinics where patients obtain free antenatal and postnatal care: (1) Mamelodi West Clinic; (2) Stanza II (LA) Clinic; (3) Phahameng Clinic; (4) Nellmapius Clinic; and (5) Holani Clinic.

2) Mpumalanga

Mpumalanga is a province in eastern South Africa, north of KwaZulu-Natal province and bordering Swaziland and Mozambique (see figure 2). It constitutes 6.5% of South Africa's land area and is the second-smallest province in the country after Gauteng. It is predominantly a rural province, with over 70% of the land being used for Agriculture. Other economic activities in the province include extensive gold, platinum and coal mining; as well as tourism (home of the Kruger National Park). Given its mining and tourism industry, the province has the fourth-largest economy in South Africa. Over 90% of the population in Mpumalanga is black/ of African descent. The most commonly spoken language in the province is SiSwati, the language of neighboring Swaziland (30%), while 26% of speak isiZulu, and about 11% speak Tsonga and 10% speak isiNdebele.[51]

The study was carried out in district hospitals, community health centers, and local authority clinics in Mpumalanga where the University of Pretoria medical students do their District Health rotation. The following sub-districts (which are mostly rural) were included in the study: Emalahleni, Umjindi, Mkhondo, Mbombela North, Mbombela South, Nkomazi East (Tonga Sub-district), Nkomazi East (Shongwe Sub-district), and Middelburg.

3) Limpopo

Limpopo is the northernmost province in South Africa. It neighbors Zimbabwe on its northeast border, Mozambique on its eastern border, and Botswana on its northwest border. Like Mpumalanga, it is predominantly a rural province, with most of the land being used for agriculture. Other economic activities in Limpopo include mining of iron ore, coal, diamonds and gold. Over 97% of the province's population is Black, predominantly from the Northern Sotho (Sepedi) ethnic group. A growing number of this province's population also includes immigrants from Zimbabwe and Mozambique. A vast majority of people in Limpopo are impoverished rural dwellers who subsist on agriculture; as well as mine workers.[69]

The study was carried out in Mopani district, one of the six districts in Limpopo. Specifically, it was conducted in Letaba Hospital, a rural district hospital in Limpopo where the University of Pretoria medical students do their District Health rotation.

3.3 SPECIFICS OF METHODS:

A : Sub-project A: Patterns & Preferences of Mobile phone use

This subproject was a cross-sectional study in which questionnaires were administered to pregnant mothers receiving antenatal care in Gauteng, Mpumalanga and Limpopo to determine their patterns of mobile phone use and their attitudes/preferences regarding the use of mobile phones in healthcare.

A.1) Target Group:

The target groups for these questionnaires were expectant women attending antenatal clinics/ women on the labor wards of the sites in the three provinces.

Inclusion criteria:

- Pregnant
- Over 15 years of age

Recruitment:

-Pregnant women visiting an antenatal clinic were randomly approached by the primary researcher (Kemunto Mokaya) or University of Pretoria medical students and asked to participate in the questionnaires as they are waiting in line to be seen. In Mpumalanga, women who had just delivered babies in hospitals were also approached for the study. In the rural sites (Mpumalanga and Limpopo), about 10 pregnant women were asked to

participate per clinic/hospital site; while in Gauteng, 10 – 20 participants were recruited per site (since fewer sites were sampled in Gauteng).

Sample size:

The target sample size was 300 participants; with a least 100 from Gauteng (representative of an urban setting) and 100 from both Mpumalanga and Limpopo (representative of a rural South African setting).

Methods:

1) Questionnaires

Anonymous questionnaires were administered to the target group to determine their patterns and preferences of mobile phone use. After obtaining the participants' informed verbal consent and giving them information sheets, the primary researcher/ University of Pretoria medical students interviewed them and recorded their responses on structured questionnaires. The questionnaires mostly consisted of questions with multiple-choice answers, but there were also a few open-ended questions. They were all written in English. Most patients readily understood the questions and answer choice options, and in the few instances where there were language barriers/misunderstandings, nursing staff readily assisted by interpreting. The questionnaires took about 10 – 15 minutes to complete. No compensation was provided to respondents for participating in the study.[**] (See Appendix **N** & **O** for the information sheet and questionnaire respectively).

[**] Participants in South African studies are typically not compensated financially for participating in questionnaires/interviews that last less than 30 minutes and are considered minimum risk (i.e. no sensitive information asked and minimal emotional discomfort expected). Participants were therefore not compensated for their participation, in accordance with common research practice in the country.

B : Sub-project B: Staff Preferences

This subproject was a cross-sectional study in which several questionnaires were administered to healthcare workers providing antenatal, postnatal, and obstetric care to mothers in Gauteng, Mpumalanga and Limpopo provinces to determine their patterns of mobile phone use and their attitudes towards incorporation of mobile phone technology to healthcare.

Target Group:

Healthcare providers in clinics and hospitals in Gauteng (mainly Mamelodi), Mpumalanga and Limpopo who are involved in the provision of maternal and infant health care services such as antenatal and postnatal care, PMTCT, labor and delivery will be approached to participate in this study.

Inclusion criteria:

- Healthcare workers willing to complete the questionnaire including doctors, nurses, health care managers, counselors, and health promoters.

Recruitment:

-Healthcare workers were approached by the primary researcher/ University of Pretoria medical students and asked to complete the anonymous questionnaires during their free

time. The following day, these completed questionnaires were collected from the healthcare workers.

-In some sites, supervising nurses were given 5 – 10 questionnaires, which they distributed to workers in their sites. The completed questionnaires were collected the following day.

-In some sites in Mpumalanga and Limpopo, the University of Pretoria medical students approached healthcare staff for interviews during their free time. The students filled the questionnaire with information provided by the healthcare workers.

Sample size:

A sample of at least 60 participants was targeted: at least 30 from Gauteng; and at least 30 from both Mpumalanga and Limpopo.

Methods:

1) Questionnaires

Willing staff members completed an anonymous questionnaire after being briefed on the purpose of the study and giving informed consent. The questionnaires were all in English, and took about 10 – 15 minutes to complete. They included open-ended questions at the beginning that explored current communication methods used by the postnatal clinics, their effectiveness, and current barriers in patient-provider communication. They also had closed-ended questions requiring multiple-choice answers. No compensation was provided to healthcare workers for participating in the

study. (Please see Appendix **P** & **Q** for the information sheet and questionnaire respectively).

Subproject C: Randomized controlled trial (RCT)

A randomized control trial (RCT) was carried out over a 4-month period, from January – April 2009, to evaluate the effectiveness of a mobile phone intervention in reminding patients to return for their postnatal visits within a week of delivery in Mamelodi. The patients were randomized to the phone call intervention group, versus the short message service (SMS) intervention group, versus the standard of care control group (see figure 3 on the following page: Consort diagram)

Setting:

- The participants for this study were recruited from the labor wards at Stanza Bopape Community Health Center and Mamelodi Hospital, in Guateng province.
- The surrounding local authority clinics, where these mothers were expected to obtain their postnatal care, were also visited to obtain information on postnatal clinic attendance rates.

Target Group:

The target group for the RCT was mothers who have recently delivered in the labor wards of Stanza Bopape CHC and Mamelodi Hospital.

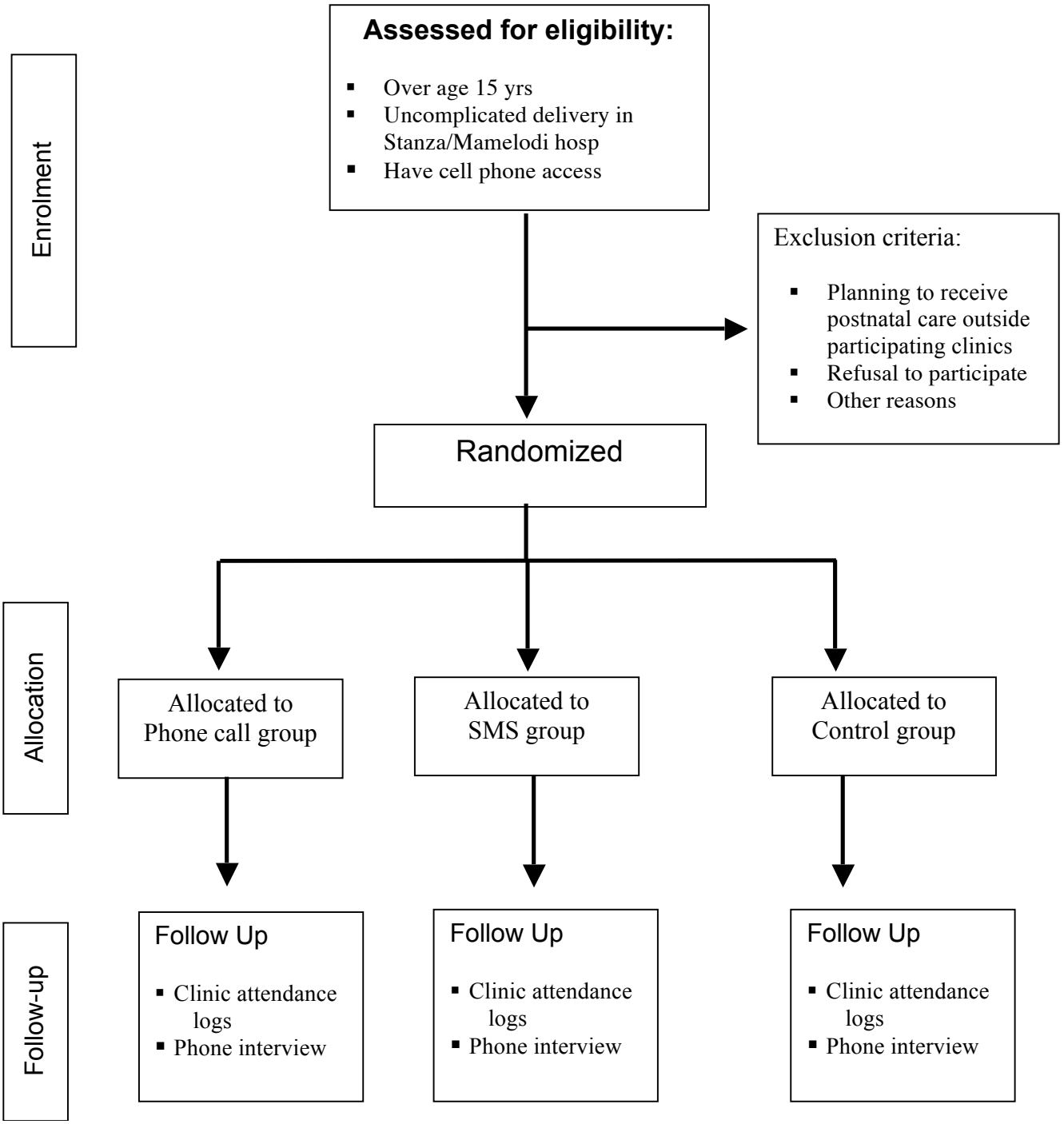
Inclusion criteria:

- Uncomplicated delivery at Stanza Bopape CHC or Mamelodi Hospital

- Over age 15 yrs

- Own/ have regular access to a mobile phone

Figure 3: Consort diagram showing recruitment plan for sub-project B (RCT)



Exclusion criteria:

- During enrollment, women were excluded from the study if they indicated that they planned to receive postnatal care outside the six local authority clinics in Mamelodi Township. Mothers planning to receive postnatal care at private clinics within or outside Mamelodi Township were also excluded.

- Mothers were excluded from analysis/follow up if they had prolonged hospitalizations exceeding three days after delivery, and also if they provided incorrect contact information and therefore could not be traced.

Recruitment:

Recruitment for the study took place in a four-month period between January – April 2009. The recruitment procedure was as follows:

1. Mothers who had recently given birth at Stanza Bopape/ Mamelodi Hospital were identified by reviewing birth logs and visiting the labor & delivery wards each morning.

2. They were approached by the primary researcher or a medical student who briefly explained about the study and the importance of the 3-day visit. They were then handed the patient information sheets and asked to participate in the study after they had gone through the information sheet and all their questions about the study were answered.

3. After reading, understanding, and signing the informed consent forms, the interview/ questionnaire was carried out; during which mothers were asked to provide their

contact information, describe their patterns and preferences of mobile phone use. The questionnaires were filled by the primary researcher/ medical students.

4. Mothers were then informed that, depending on which group they would be randomized to, they should expect a phone call/SMS from the primary researcher reminding them to attend their follow-up visit.

Sample Size:

As shown in a previous study in South West Tshwane (unpublished data), about 51% of women return for postnatal visits at 3 days. The minimal difference we wished to detect between the groups that would indicate a potentially effective intervention was 15%. With an alpha error of 0.05 and a beta error of 0.8, the sample size needed was estimated to be 126 in each group. Therefore, N for the study was calculated as 378 participants. Assuming that about 5 – 6% of the participants (about 22 participants) would be excluded from analysis due to reasons such as prolonged hospitalizations, a total sample size of 400 participants was calculated, with a minimum of 130 participants in each arm of the study.

In part 2 of this sub-project, mothers who received phone call or SMS reminders were surveyed to determine their satisfaction with the reminders. The target sample size was at least 75% of participants per intervention group, leading to a total of a minimum goal of 170 participants for the satisfaction survey.

Methods:

1: Questionnaires / Interviews

After obtaining written informed consent, patients were interviewed by the primary researcher/University of Pretoria medical students and their responses were filled in questionnaires to obtain information such as the mothers' patterns and preferences towards mobile phone use and their contact information. The questionnaires were all written in English, and in instances when participants could not communicate adequately in English, nurses were readily available to translate the questions/answers. These questionnaires took about 15 – 25 minutes to fill, and consisted mainly of structured questions with multiple-choice answers as well as several open-ended questions. Participants were not compensated for their involvement in this study (See "RTC Questionnaire & Informed consent forms).

2: Randomized Control Trial

There were three arms in the RCT:

i) Control group: In which standard methods of reminding patients to return for follow up within one week of delivery (verbal reminder by the nurses at discharge) were used.

ii) Intervention group I: In which mothers were sent a text message on day 2 after delivery (the day before their 3-day visit) with a message similar to the message below. All text messages were written in English. The standard message was:

"Dear [First name] [Last name], this is a reminder to go to [clinic name] for your 3-day postnatal check up on [date of 3-day check up]. Please remember to visit the clinic by [date one week after delivery]. Thank you."

iii) Intervention group II: In which mothers received a phone call on day 2 after delivery (the day before their 3-day visit) from the primary researcher reminding them to visit their postnatal clinics within a week of delivery. A standard message, which was delivered in English, was used to avoid unequal intervention. It was as follows:

"Hello. May I please speak to [Full Name]…. Hi [First Name], I am calling from [name of hospital where delivery was carried out] to remind you to attend your 3-day check up on [Date of visit]. Please remember to visit the clinic by [date one week after delivery]. Thank you."

A maximum of three calls were attempted (using the number listed by the participant as her primary number), and on the third call, a voicemail message was left with a message similar to the text message script. If no voicemail was available, the primary researcher attempted to reach patients using any alternative numbers provided. One patient was not reached using any of the numbers she provided and was therefore excluded from the study.

-The time and length of the calls were be recorded for purposes of time and cost monitoring. (See Appendix **I** for sample of call-log used during study).

Randomization:

The participants were randomly assigned into groups after recruitment at the end of the day (to make the researchers blinded to the intervention that will be used at the point of patient recruitment). An online research randomizer was used to randomly generate codes – either 00 (control), AA (group A) and BB (intervention group B) – which will be randomly assigned to mothers recruited during the day.

- Over 90% of the patients in the study were randomized into their groups using the randomly generated codes.
- On two occasions, all the patients recruited on a certain day were all assigned into the control group, because the primary researcher was not in a position to send the SMS or call the patients on day 2 after delivery. To maintain a 1:1:1 allocation ratio, on two separate days, patients were only randomly allocated to the SMS versus call groups only.

3: Follow Up Telephone Interview:

All participants were contacted one to three weeks after delivery by telephone for the purposes of:

a. Determining their satisfaction with the reminder to attend their 3-day visit (for only patients in the SMS/ Phone call group. At least three quarters of the participants in these two groups were asked questions about their satisfaction with the reminders and reasons for their levels of satisfaction).
b. Determining whether they went for their 3-day visits, finding out how these visits went, and also whether any complications were detected.

c. Finding out reasons for non-attendance in mothers who did not return for their follow-up visits within a week.

4: Record Review:

- Postnatal records were reviewed at Stanza Bopape Community Health Center (CHC), Mamelodi Hospital, and the surrounding postnatal clinics to determine whether participants recruited for the RCT returned for their postnatal visits within a week of delivery. To make it easier to track which patients attended their postnatal visits, the nurses at the postnatal clinics also kept a log summarizing patients names, the attendance dates, and any complications detected during the visit. Attendance data on was recorded on an attendance sheet (see Appendix **K**).[††]

- To obtain a baseline rate of postnatal clinic attendance, birth logs and registers at Stanza Bopape CHC and Mamelodi Hospital were reviewed to obtain the names of mothers who delivered during weekends/ holidays, and their respective antenatal clinics. During visits to postnatal clinics, attendance logs were checked to determine whether these mothers attended their one-week visit at their respective postnatal clinics (see Appendix **L**).

5: Observation:

The primary researcher noted down any differences she observed between the various postnatal clinics and sites of delivery involved in the study. She paid

[††] Not all postnatal clinics were consistent at documenting whether participants returned for the 3-day visit, especially at the beginning of the study. Therefore, in addition to using available postnatal records, follow up telephone calls were also used to determine whether participants returned to clinic.

attention to factors such as facility type, patient-provider ratios, patient-provider communication, and record-keeping.

6: Cost Analysis:

Records of all phone calls (time of calls, length of calls, and costs of calls) as well as records of all text messages sent were documented on a daily basis (see record sheet in Appendix **P**). A cost analysis was carried out at the end of the study to compare how much it cost to implement the different interventions.

3.4) ANALYSIS PLAN:

I) Sub-projects A & B:

Data from the first two sub-projects were stored Access files, which were converted to Excel files and SPSS. The data were mainly analyzed descriptively, using graphs and tables to represent findings such as participant characteristics, their patterns and preferences of mobile phone use, and attitudes towards mHealth.

-Cross tabs and chi square tests were done using SPSS to determine whether certain participant variables such as age, employment status, education level, and location (rural versus urban setting) influenced patterns of mobile phone use such as frequency of use, and functions used on mobile phones (in sub-project A).

-Qualitative data from open-ended questions and from clinic observations were compiled and coded appropriately.

II) **Sub-project C: Randomized Controlled trial**

-Data analysis for the RCT included use of charts and tables to analyze and report descriptive data such as characteristics of the sample and the patterns and preferences of mobile phone use in participants.

- For the primary outcome (determining whether the SMS or phone call interventions increased postnatal attendance rates), bivariate analyses were done using chi square tests. For calculations such as the non-attendance odds rations, the control group was used as the reference group. To identify factors that might have influenced attendance rates (such as site of delivery, education levels of mothers, antenatal clinic, and so on), chi square tests were carried out. Multivariate logistic regression was also carried out using SPSS to correct for variables that may have contributed to differences in rates of attendance between the three groups in the RCT.

- For secondary outcomes such as patient satisfaction with reminders, outcomes were reported using tables and charts. Chi square tests were also used to determine whether there was a significant difference in satisfaction levels between participants in the SMS versus phone call group

-Cost analysis was done by simply calculating the total costs spent on phone calls and SMS'es, and dividing these by number of calls/ SMS to determine unit costs of each method.

4. RESULTS:

Sub-project A: Patterns & Preferences of Mobile phone use

The results for sub-project A, which aims at determining patterns and preferences of mobile phone use among respondents, are presented under ten sub-headings corresponding to the ten research questions associated with the sub-project.

4.A.1: Characteristics of Patients:

A total of 375 participants attending antenatal clinics in three provinces were recruited for the study: 149 of them were from Gauteng province, 15 from Limpopo province, and 211 from Mpumalanga. The participants represented 28 clinics and hospitals: 7 in Gauteng, 1 in Limpopo, and 20 in Mpumalanga. Their ages ranged from 15 to 45 years of age, with a mean age of 25.3 years and a median of 24 years. Most of the subjects were unemployed (71.7% unemployment rate); and about a fifth of them reported living in a home without electricity, indicating lower socio-economic status. (See table 1 below).

The subjects surveyed from Gauteng (N = 149, approximately 40% of the total) are representative of lower-income dwellers in urban settings in South Africa; while the respondents from both Limpopo and Mpumalanga (N = 226, approximately 60% of the total) are representative of rural views. Given the small sample size from Limpopo (N = 15), the data from provinces will be compared using “urban” and “rural” classification, with urban representing Gauteng, and rural representing pooled data from both Mpumalanga and Limpopo.

Table 1: Characteristics of participants surveyed		
Characteristics		**n = 375 (%)**
Age (mean ± SD)		25.3 ± 6.1
Education Level		
	Primary school or less	89 (23.7)
	Some high school	127 (33.9)
	High school graduate	106 (28.3)
	Tertiary degree	53 (14.1)
Province where located		
	Gauteng	149 (39.7)
	Mpumalanga	211 (56.3)
	Limpopo	15 (4.0)
Employment		
	Employed	106 (28.3)
	Unemployed	269 (71.7)
Electricity at home?		
	Yes	270 (72)
	No	76 (20.3)
	Unreported	29 (7.7)
Preferred Language		
	English	103 (27.5)
	IsiZulu	106 (28.2)
	SiSwati	64 (17.1)
	Sotho	32 (8.5)
	Other	70 (18.7)

The mothers represented different education levels. Basically, about 60% of them had a primary school education or had began high school, 28.3% of them were high school graduates who had completed and passed their "matric" examination (post-secondary examination in South Africa), and 14.1% of them had tertiary education (see figure 3 below).

Table 2 compares the characteristics of respondents in the urban versus rural provinces. There are no statistically significant differences between the groups in terms of age and education level. However, there are differences in employment: 37.6% of urban respondents had jobs compared to 22.1% of rural respondents ($p = 0.001$),

indicating that out sample represents the general trend in South Africa where more economic opportunities are available in urban areas as opposed to rural areas.

There are also differences in preferred languages of communication between provinces. In Limpopo, 12.15 (80%) of the subjects listed Tsonga as their preferred language of communication; while in Mpumalanga, the preferred languages were: IsiZulu 81/211 (38.4%), SiSwati 63/211 (29.9%) and English 40/211 (19%). In Gauteng, the preferred languages of communication were: English 63/149 (42.3%), IsiZulu 25/149 (16.8%) and SeSotho 25/149 (16.8%). In comparing English versus all other languages, there were significantly more participants who listed English as a preferred language in Gauteng (42.3%) versus Mpumalanga and Limpopo (17.7%) ($p < 0.001$).

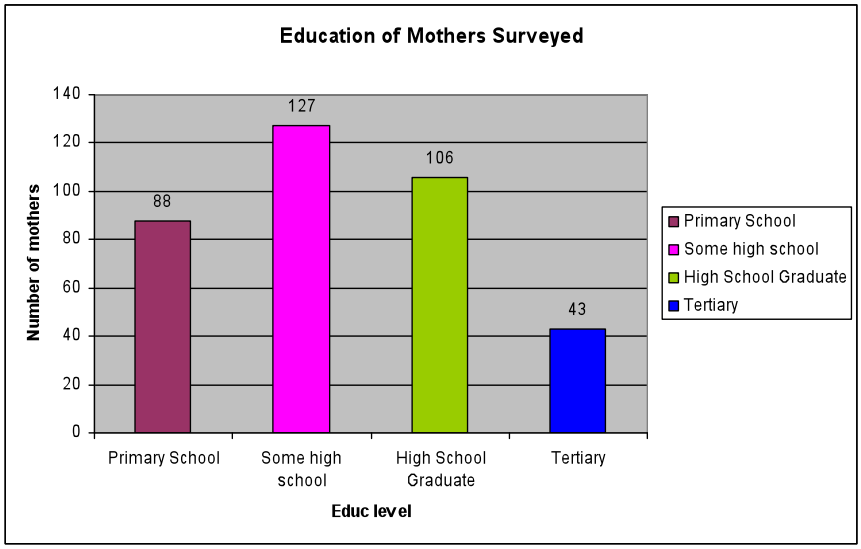


Figure 3: Education levels of mothers in sub-project 1

Table 2: Characteristics compared by province

	Characteristics	Urban*	Rural*	P
Number		149 (39.7)	266 (60.3)	-
Age (mean ± SD)		26 ± 6	25 ± 6.2	0.38
Education level				
	Completed high school	67 (45)	92 (40.7)	0.41
	High school or less	82 (55)	134 (59.3)	
Employment				0.001
	Employed	56 (37.6)	50 (22.1)	
	Unemployed	93 (62.4)	176 (77.8)	
Electricity at home?				
	Yes	100 (67.1)	170 (75.2)	
	No	20 (13.4)	56 (24.8)	
	Unreported	29 (19.5)	0 (0)	
Preferred language				
	English	63 (42.3)	40 (17.7)	< 0.001

* Urban = Gauteng province, Rural = Limpopo & Mpumalanga provinces

4.A.2) Access to Telephones:

Table 3: Access to Telephones

	Phone Access:	Urban	Rural	Total	p
1	Have landline phone	15 (10.1)	31 (13.7)	46 (12.3)	0.13
2	Have mobile phone access	146 (98)	216 (95.6)	366 (98)	0.26
3	Own personal mobile	121 (81.2)	181 (80.1)	302 (80.5)	0.43
4	Reachable by 2 or more numbers	74 (49.7)	95 (42)	169 (45.1)	0.15

*Urban = Gauteng province, Rural = Limpopo & Mpumalanga provinces

An overwhelming majority of respondents had access to mobile phones (98%). (See table 3 above and figure 4 below). Of the 375 patients sampled, 302 of them (80.5%) owned their own personal mobile phones, while about 17% of them relied on

close contacts (either family members or neighbors or friends) for mobile phone access. There was not a significant difference in mobile phone access between rural and urban dwellers. Note that only a small percentage of these subjects (12.3%) had access to landline telephones, and that there was no statistically significant difference in access to landline phones between urban and rural areas.

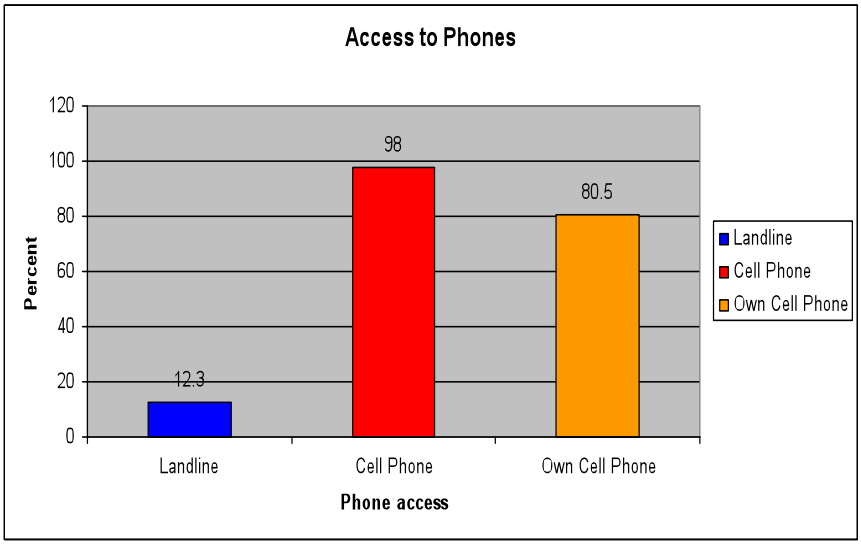


Figure 4: Access to telephones among respondents

When statistical analysis was done to determine what variables affected owning personal mobile phones using chi square tests, there were associations between ownership of cell phones and higher levels of education and employment: 90.6% of people who had completed high school owned their own phones, as opposed to 73.1% of people who had not completed high school ($p > 0.001$). Also, 92.5% of employed respondents had personal mobile phones, as opposed to 75.8% of unemployed respondents. ($p > 0.001$). There were also associations between age group and ownership of personal mobile phones. Respondents aged 22-29 years had the highest rates of

owning personal phones (86.5%), compared to 81.1% in subjects over 30 years and 72.3% in those between age 15-21 years (p = 0.04).

4.A.3) Use of Mobile Phones:

Most of the respondents reported using their mobile phones to make and receive calls (95.2% and 96.8% of respectively). A large percentage of the respondents also used their mobile phones to send and receive text messages (80.5% and 81.6% respectively). A little less than half (46.9%) of patients reported using their phones to retrieve voicemails, while only a small fraction of subjects (3.2%) reported using their mobile phones for internet access (see figure 5 below).

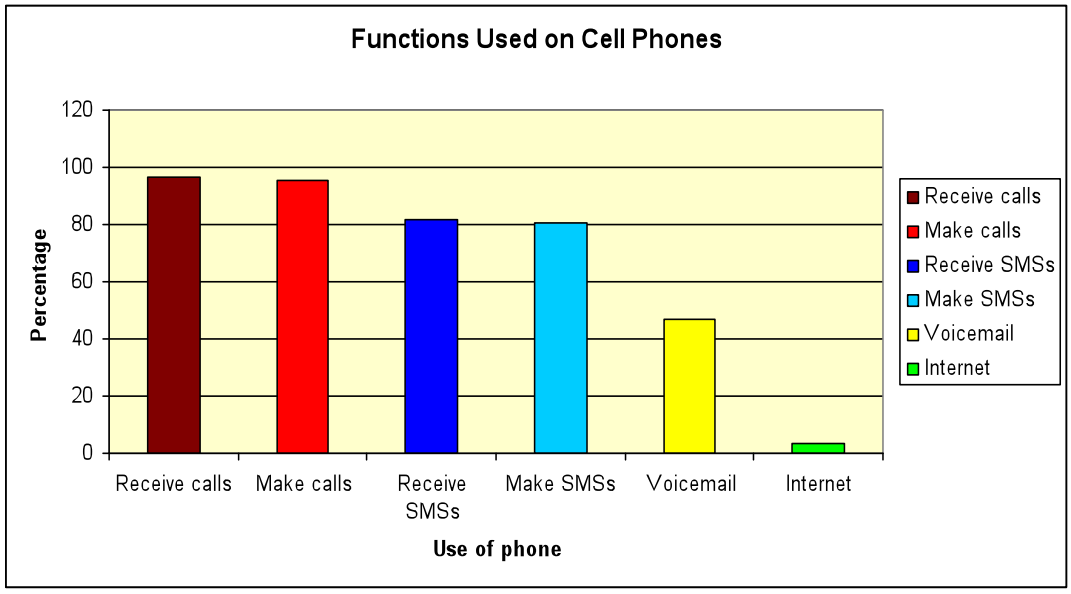


Figure 5: How patients use their cell/mobile phones.

When subjects from the different provinces were compared to determine whether there were rural-urban differences in their use of mobile phones (in terms of phone calls

versus text messages versus voicemail and the internet), there was no statistically significant difference in mobile phone use between the groups (see Table 4 below).

Table 4: Uses of Mobile Phones

Phone Use		**Urban**	**Rural**	**Total**	**P**
1	Receive calls	146 (98)	217 (96)	363 (96.8)	0.29
2	Make calls	145 (97.3)	212 (93.8)	357 (95.2)	0.12
3	Receive SMS	122 (81.9)	184 (81.4)	306 (81.6)	0.91
4	Send SMS	120 (80.5)	182 (80.5)	302 (80.5)	0.99
5	Voicemail	69 (46.3)	107 (47.3)	176 (46.9)	0.84
6	Internet	6 (4)	6 (2.7)	12 (3.2)	0.46

When analyses were performed to determine whether factors such as age, education level, employment, and preference of English as the language of communication affected mobile phone use, the following factors were found to affect mobile phone use:

1) Age: Younger people were more likely to use mobile phones to send and receive text messages than older people. 83.1% of respondents aged 15 – 21 years and 84.5% of respondents aged 22 – 29 and used phones for text messages compared to 70% of respondents aged 30 years and over ($p = 0.014$).

Younger patients (age 29 and below) were more likely to use their mobile phones for a wide range of functions outside of phone calls and text messages. All of the twelve patients that reported using their mobile phones for internet access were 29 years and under (ranged from age 17 to 27 years). Patients aged 20 and under also reported using their mobile phones for games, as radios, alarm clocks, for photography, and as calculators.

2) Education level: 91.2% and 91.8% of respondents who had completed high school used phones to send and receive text messages respectively; compared to 72.7% and 74.1% of respondents who had not yet completed high school ($p > 0.001$). Additionally, 100% of respondents who had finished high school used their phones to make calls, while only 91.7% of those who had not finished high school used their phones to make calls ($p > 0.001$). Higher education levels were therefore associated with increased use of phones – both to make calls, and also to send/receive text messages.

4.A.4) Frequency of Use of Mobile Phones:

Figure 6 illustrates the frequency of mobile phone use among respondents. Most respondents reported using mobile phones at least every day (79%), with over 16% of them reporting use of their phones over five times daily, and some of them reporting use of their phones over ten times a day on a consistent basis (also see table 5 below).

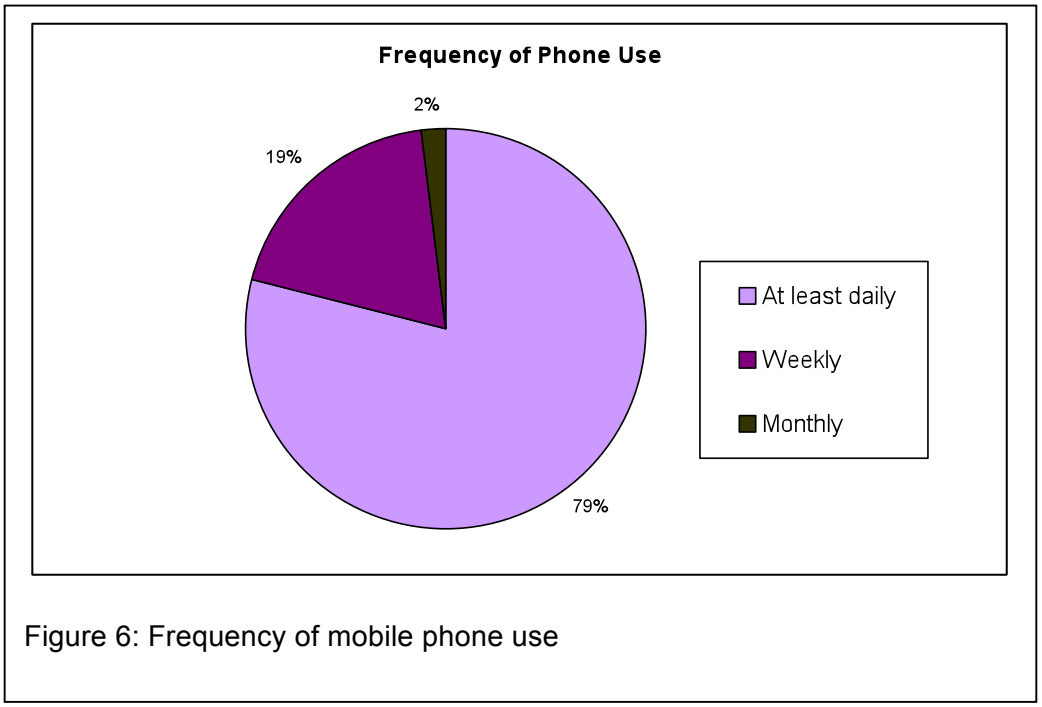


Figure 6: Frequency of mobile phone use

There was a statistically significant difference in frequency of phone use between rural and urban areas, with urban respondents using their phones more frequently than rural respondents (p = 0.02). When chi square tests were used to determine whether variables such as age, education level, and employment level affected frequency of mobile phone use, there was also an association between education level and frequency of phone use, with people who had finished high school having a higher likelihood of using their phones daily. Age was also associated with frequency of use: respondents aged 22-29 years were more likely to use phones daily (82.6%); than those aged 15-21 years (75%), or those over 30 years (64.4%) (p = 0.04).

Table 5: Frequency of Mobile phone use

Frequency of Phone Use:

	In ppl using phones:	**Urban**	**Rural**	**Total**	**P**
1	At least daily	125 (83.9)	171 (75.7)	296 (78.9)	0.02
2	Weekly	22 (14.8)	50 (22.1)	72 (19.2)	
3	Monthly	2 (1.3)	5 (2.2)	7 (1.9)	

4.A.5) Prior contact with healthcare providers via mobile phones

Only three patients in Gauteng reported being contacted by healthcare staff on their mobile phones, while no patient in Mpumalanga or Limpopo reported ever being contacted by healthcare providers via the telephone/ their mobile phones. The reasons why these three Gauteng patients were called were to be given pregnancy results, to

discuss HIV test results, and to clarify information for a patient enrolled in a research study.

4.A.6) Views towards contact with Healthcare providers using mobile phones

When asked what they felt regarding communication with healthcare providers on their mobile phones, most respondents were very positive towards it, with 86% of them feeling that it was a good idea to use mobile phones in patient-provider communications (see figure 8 below). 7% and 2% felt it was a bad idea and very bad idea respectively. They did not elaborate why they felt it was a bad idea.

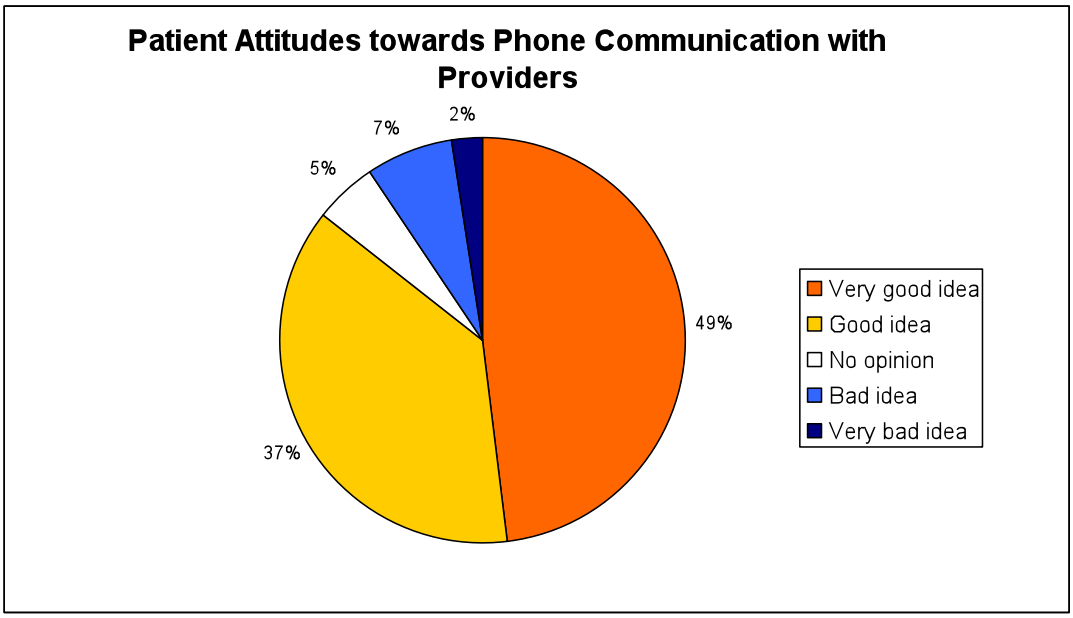


Figure 8: Patient attitudes/opinions regarding communication with providers

There seemed to be no statistical difference in patient attitudes between the urban and rural provinces regarding whether they felt it was a good idea for providers to reach them on their phones (See table 6 below). Analysis with chi square tests also found that factors

such as: age, education level, employment and preferred language did not influence patient attitudes regarding communication with healthcare providers.

Table 6: Views regarding communication with health providers on cell phones:

Opinion	Urban	Rural	Total	P
Very good idea	69 (46.3)	111 (49.3)	180 (48.1)	0.54
Good idea	62 (41.6)	78 (34.7)	140 (37.4)	
No opinion/ Neutral	8 (5.4)	11 (4.9)	19 (5.1)	
Bad idea	8 (5.4)	18 (8)	26 (7.0)	
Very bad idea	2 (1.3)	7 (3.1)	9 (2.4)	

4.A.7) Preferred communication mode/ method

Most respondents (97.6%) reported that their mobile phones were the best way to reach them. Nine subjects (2.4%) preferred to be reached via an alternate number (work phone and home landline numbers).

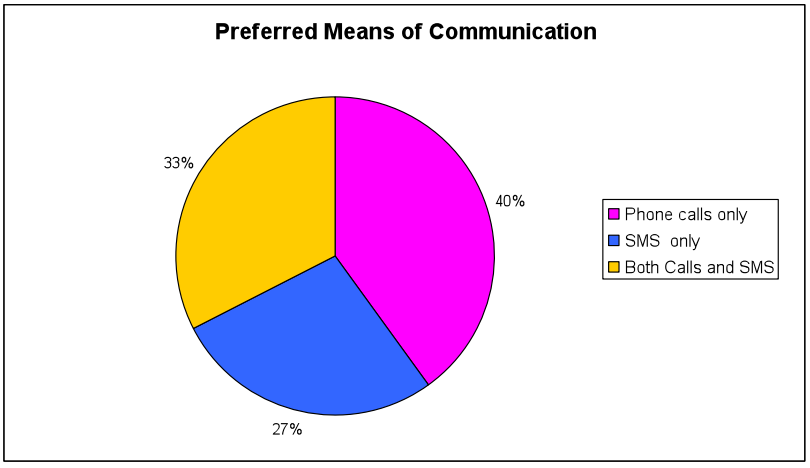


Figure 9: Preferred means of communication

In terms of preferred mode of communication, 148/375 subjects (40.1%) reported a preference for phone calls only. 120/375 (32.5%) of them were open to both phone calls and text messages; while 101/375 (27.4%) respondents preferred text messages only with

there being a greater preference for phone calls in urban areas (see figure 6 above and table 7 below).

Table 7: Preferred means of communication:

	Urban	Rural	Total	P
Both phone calls and SMS's	60 (40.3)	61 (27.6)	120 (32.5)	<0.001
Phone calls only	67 (45)	81 (36.7)	148 (40.1)	
SMS's only	22 (14.8)	79 (35.7)	101 (27.4)	

In examining factors that affected preferred means of communication, it was found that older respondents (over 30 yrs) preferred phone calls only, while respondents who graduated from high school were likely to prefer/ appreciate both means of communication.

4.A.8) Type of Information to communicate using mobile phones

Most patients were open to receiving appointment reminders (86.9%), educational messages (72.2%), and medication reminders (64.2%) from healthcare providers on their mobile phones. About half of them (52.5%) felt it was appropriate to deliver test results via mobile phones. There were no statistically significant differences among respondents from different provinces, age groups, or education levels regarding types of information to communicate; with one exception: appointment and medication reminders. 93.1% and 71.1% of patients who had finished high school indicated willingness to receive appointment and mobile reminders on their mobile phones respectively; compared to

82.4% and 58.8% in respondents who had not graduated from high school. (p= 0.002 for appointment reminders; p = 0.014 for medication reminders).

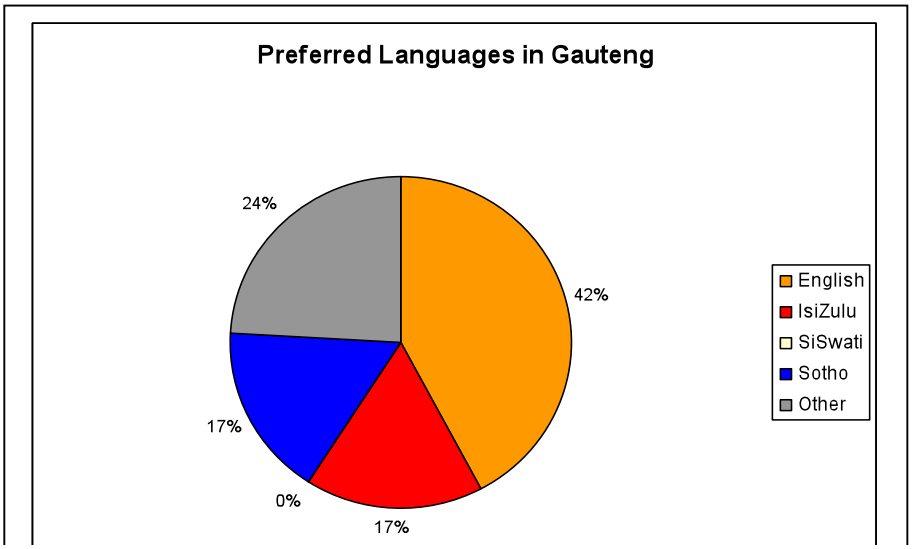
When respondents were asked what mode of communication they preferred to use if they had to communicate with providers, about half of them reported that they would call, while 27% reported that they would send an SMS. About a fifth of the respondents indicated that they would send a "please call" message to the clinic/hospital if these capabilities were available, so that the hospital could call back.

4.A.9) Preferred times for communication

Many respondents indicated that they were open to hearing from healthcare staff any time during the day. Those that indicated a specific time preferred morning hours to afternoon or evening hours.

4.A.10) Preferred languages of communication

Finally, when patients were asked about their preferred languages of communication, their responses correlated to the distribution of ethnic groups in their locations. In Gauteng, the preferred languages, in order were: English,



IsiZulu and SeSotho (see fig 10 below).

In Mpumalanga and Limpopo, only 17% of respondents listed English as their preferred language as opposed to 42% of the respondents in Gauteng. (See figure 11 below). The preferred languages of communication in Mpumalanga were as follows: IsiZulu (38.4%), SiSwati (29.9%) and then English (19%). In Limpopo, the preferred language of communication was Tsonga. 12 out of 15 (80%) of respondents listed it as their preferred language of communication. There is therefore substantial variation in language of preference by province.

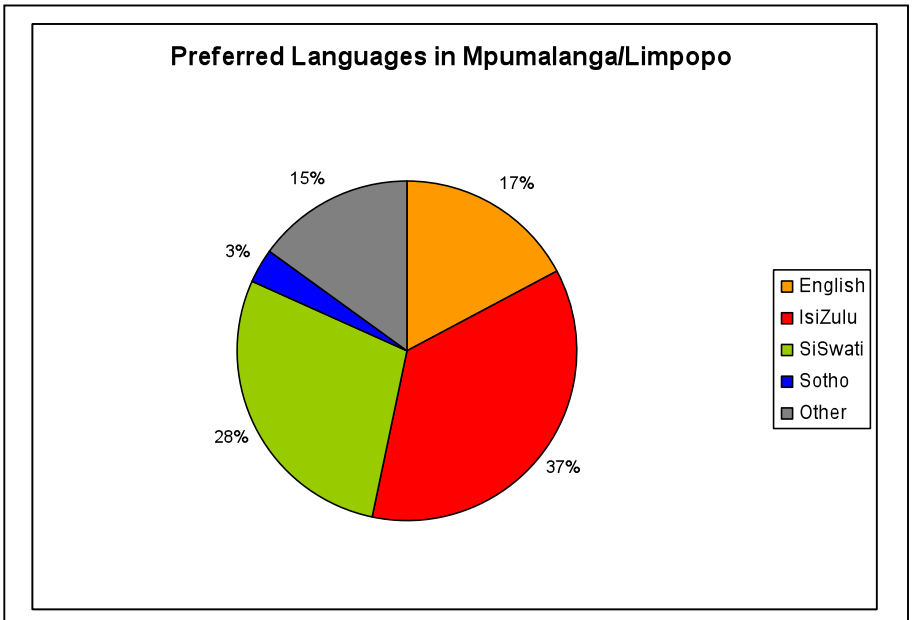


Figure 11: Preferred languages of communication in Mpumalanga and Limpopo

Sub-project B: Staff Questionnaires

The results for sub-project B will be presented under 10 sub-headings that correspond to the research questions that were outlined in the statement of purpose.

4.B.1: Characteristics of Staff Surveyed

135 healthcare workers from Gauteng, Mpumalanga, and Limpopo were interviewed to determine their views regarding incorporating mobile phones to healthcare. About 40% of them worked in ante/postnatal clinics; while 60% of them were hospital staff. About 55% of them represented rural South Africa (Mpumalanga and Limpopo), while 45% of them were from Gauteng (see table 8 below).

Table 8: Characteristics of staff surveyed

	Characteristics of Staff		N (%)
1	Number surveyed		135 (100)
2	Setting:	Clinic	55 (40.7)
		Hospital	80 (59.3)
3	Provinces	Gauteng	61 (45.2)
		Mpumalanga	55 (40.7)
		Limpopo	19 (14.1)

3	Cell Phone Use		
		Own personal cell phone	133 (98.5)
4	Functions:	Calling	132 (97.8)
		SMS	121 (89.6)
		Internet	58 (43)
		Radio	43 (31.9)
5	Use phone at least daily		> 95%

Information about their use of mobile phones is as follows: 133/135 (98.5%) of them reported owning personal mobile phones. More than 95% of them reported using their mobile phones at least once daily. Almost all of them 132/135 (97.8%) reported using mobile phones to make phone calls; while 121/135 (89.6%) of them used mobile phones for text messaging. Fifty eight (43%) and 43 (31.9%) of the healthcare staff reported using their phones for internet access and as a radio respectively. There were no statistically significant differences in frequency and functions of mobile phone use between participants from the different provinces.

Note that rates of mobile phone ownership among healthcare workers are significantly higher than those of their patients (98% of staff own their own phones compared to 83% in their patients). They also use their phones more often (95% of staff reported using mobile phones on a daily basis compared to 79% of antenatal clinic patients). Healthcare staff also used their mobile phones in more ways than their patients – for example, 43% of staff use the phones for internet access as opposed to 3% of patients. This observation is consistent with our other findings that higher education levels and employment (therefore higher income levels) are associated with increased use of mobile phones and mobile phone functionality.

4.B.2: Communication methods currently used in clinics/hospitals:

The methods used by healthcare staff to communicate with their patients, outside the patient-provider encounter, include written materials such as posters, notice boards, pamphlets, and cards – for example appointment cards and antenatal cards, and letters mailed to their addresses with information such as lab values. Among written media, posters and notice boards are used most commonly, while letters were only mailed occasionally. Other than written modes of communication, many respondents, especially those in the rural areas, reported using health promoters, who carried out home visits, to reach out to their patients. Health promoters were commonly used to administer directly observed treatment of tuberculosis (DOTS) as well as other services.

A few healthcare staff – notably staff in one of the rural provinces, Mpumalanga – reported using phone calls on a frequent basis to call patients to discuss important test results with them. Staff in the urban areas also reported using phones to communicate with patients occasionally, especially regarding urgent matters. Very few respondents also reported using mass media such as the radio, and also leaders of the community to communicate public health information.

Regarding types of information communicated to patients outside the patient-provider interaction, the type commonly cited by respondents was general health education, which was accomplished by posters, notice boards and health promoters. Test results were also sometimes communicated with patients via phone calls, or occasional letters in some instances. A few respondents also reported using phone calls/ appointment cards/ health promoters for appointment and medication reminders.

4.B.3 Effectiveness of current communication methods:

About half (52%) of all the healthcare staff felt that their current communication methods were effective, while about a third (30%) of them felt that their current communication methods were ineffective, and a fifth were neutral. There were differences in the views of respondents based on their provinces: 62% of the respondents from the rural provinces of Limpopo and Mpumalanga felt that their current communication methods were effective, while only 40% of staff in Gauteng felt their methods were effective.

The general theme among respondents was that methods which involved direct communication with patients such home visits by health promoters or phone calls from providers where very effective; while less personal methods such as posters, pamphlets, notice boards, and the use of mass media were just moderately effective. Mailed letters and appointment cards were generally thought to have low efficacy. Of note, respondents from rural areas listed use of more personal communication methods such as home visits more commonly than urban respondents.

The barriers to effective communication and proposed solutions by healthcare workers to improve provider-patient communication are listed below. In general, respondents who felt that current communication methods were inadequate gave more comprehensive lists of current communication barriers.

4.B.4 Barriers of current communication methods:

Reasons cited for barriers to effective communication included patient factors such as patient illiteracy; language barriers (especially when patients did not speak the

dominant language spoken in a particular region); low knowledge levels/ ignorance in patients – partly due to limited time available in hospitals/clinics to adequately counsel patients about their conditions; cultural beliefs of patients that prevented patients from adhering to healthcare workers' recommendations; forgetfulness of patients; and difficulties reaching patients – for example in instances where they changed their addresses and phone numbers without alerting healthcare providers and therefore making it difficult to follow up with them via home visits or phone calls.

The respondents also identified systemic factors that contributed to ineffective communication with patients. These included inadequate personnel to communicate with patients (for example phone calls or home visits); inadequate resources/ funding to improve current communication methods; lack of time; the use of a limited variety of communication methods (for example, some respondents mentioned using just posters and notice boards to reach out to patients outside their provider-patient encounter); and poor filing/ record keeping, leading to loss of patient information.

Solutions:

The respondents listed many solutions to improve current communication methods as follows:

1) Increasing numbers of healthcare staff to allow them to spend more time seeing and educating patients in clinics/ hospitals.

2) Having more forms of written communication in clinic such as a varied range of posters in clinics. Also, increasing the variety and availability of pamphlets/ information

sheets that patients can take home with them to educate themselves about their conditions.

-It was also noted that these posters/ pamphlets should be made available in multiple languages to enable patients to understand them better.

3) Use of patients' mobile phones to communicate with them by calling and text messaging.

4) Having toll-free numbers for clinics and hospitals, which patients can call at no cost to obtain specific health information (and possibly hiring dedicated healthcare workers to man the lines).

5) Use of different communication methods, such as audio-visual methods because they are more interactive. For example, having televisions in waiting rooms that play health education videos; or having patient education days in which patients viewed educational videos and then had a question/answer session with nurses afterwards.

6) Better basic health education in primary and secondary schools to increase patients' baseline levels of knowledge.

7) Computerization / storing patient information electronically, to enable providers to better track their patients' care and to enable them to pass on information (such as print-outs of test results) more easily to patients

8) More home-visits by health promoters. Also, expanding the scope of health promoters – for example, training them to carry out tasks such as follow up of mothers/babies after delivery to ensure that they are fine.

9) Having more hospital open-days/ health campaigns where information on specific diseases can be provided and questions answered.

10) More widespread use of mass media, such as radio advertisements, local newspapers, and the television to better educate patients on healthcare issues.

4.C.5: Use of mobile phones for various types of communication:

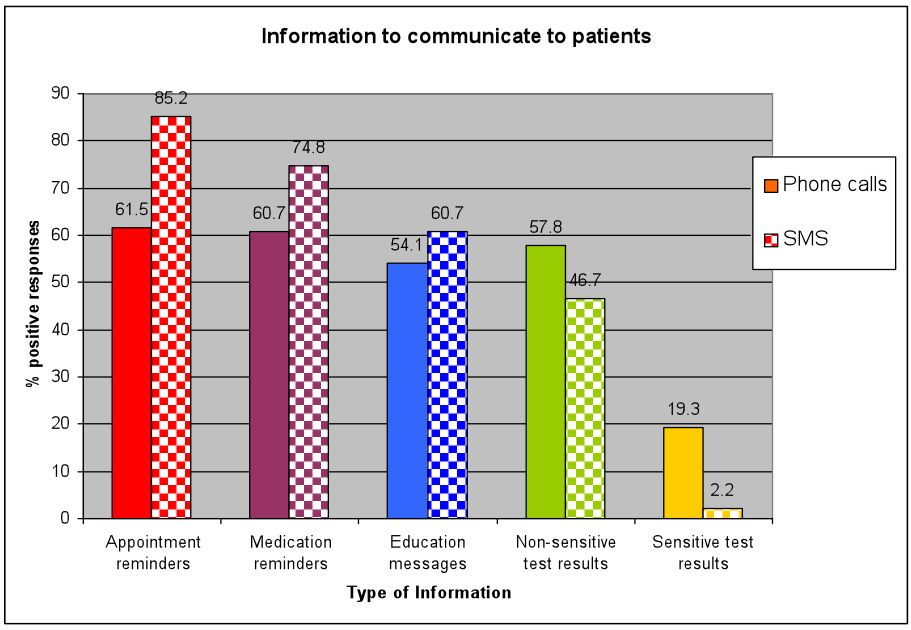


Figure 12: "Yes" responses regarding info to communicate by SMS

For one of the questions, the healthcare workers were provided with a list of different types of information that could be provided to patients and asked to indicate whether they felt it would be appropriate to communicate these types of information either by calling the patients or sending them text messages (see table 9 below).

Table 9: Staff views about information to communicate by phone call/SMS

Type of information		Call N* (%)	SMS N* (%)
1	Non-sensitive test results	78 (57.8)	63 (46.7)
2	Sensitive test results	**26 (19.3)**	**3 (2.2)**
3	Medication reminders	82 (60.7)	101 (74.8)
4	Appointment reminders	**83 (61.5)**	**115 (85.2)**
5	Education messages	73 (54.1)	82 (60.7)

** The numbers under the "Call" and "SMS" columns represent responses were staff said "Yes"*

Text messages were the preferred mode of communication in all types of information except in the delivery of test results (See figure 12 above. In the figure, fully-filled bars and checked bars represent phone calls and SMS'es respectively).

The respondents were also asked to comment on their responses regarding the use of mobile phones to communicate various types of information to patients. Their responses are presented below:

i) Non-sensitive test results:

More than half (58%) of the healthcare workers felt that non-sensitive test results could be communicated to the patients by calling them; 47% felt that text messages were fine in delivering non-sensitive test results. Most of the reasons cited for not using SMS to communicate test results were that results can be confusing, and patients would need verbal explanations about what their results meant in person/ on the phone to ensure they understood their results. Some of those who said "yes" to SMS test results mentioned that patients should be educated about the meanings of test results as they are taking the test,

thus eliminating the need of calling them/ meeting face-to-face with them to explain results. A number of the staff who responded positively to communicating non-sensitive results by phone call or SMS were enthusiastic about shortening patient queues in clinics by communicating this information to them directly on their phones.

ii) Sensitive test results:

A few respondents (19%) indicated that a phone call could be used to relay sensitive test results, such as HIV results to patients. Of these respondents, most of them noted that they would only deliver negative HIV results to patients on the phone; but then they would just inform them to come to clinic (without revealing test results) if the patients were HIV-positive. Only 2.2% of respondents reported that SMS can be used to report sensitive test results. The overwhelming majority of respondents felt that HIV results and counseling should be provided face-to-face. Many of them also felt that there would be privacy issues if results were sent by SMS, especially among patients who shared phones with family members.

iii) Medication Reminders:

Most respondents (61%) felt that phone calls would be appropriate to remind patients to take medications, since this would be helpful in increasing adherence, and providing guidance. More respondents (75%) felt that SMS's would be more appropriate for medication reminders. Those who said "no" to calling patients indicated that it would

be too expensive and time-consuming. Interestingly, there was a statistically significant difference ($p = 0.03$) between the responses of staff from rural and urban provinces regarding use of calls to remind people to take medications. Over two thirds (68.9%) of Mpumalanga/Limpopo respondents felt calls should be made to patients regarding medication, compared to half (50.8%) of the healthcare staff from Gauteng.

iv) Appointment Reminders:

Most respondents (85.2%) felt that SMS's would be appropriate for appointment reminders, while (61.5%) of them felt that phone calls were also appropriate for the reminders. A few concerns were raised that appointment reminders via phone call might be too time-consuming and would also be too expensive. Few staff members who responded "no" to reminders by phone call or SMS claimed that they were redundant since appointment card systems already existed. Interestingly, there was statistical significance in differences between staff from different provinces regarding using phone calls for appointment reminders. Most staff in the rural areas (78.4%) felt that felt that phone calls may be used for appointment reminders, while (41%) of staff in Gauteng felt that patients should be phoned to be reminded of appointments ($p < 0.001$).

v) Education Messages:

About 54.1% of respondents felt that educational messages could be communicated via phone calls, while 60.7% of them felt that they could be sent via text messages. Some of those who said "no" to use of phone calls or SMS reported that

education is best done verbally, in person to allow questions to be asked. Those who preferred SMS felt that patients could refer to the messages over and over again; and could also forward these to other people.

v) Other information:

Other information that the respondents felt that they could communicate to patients via SMS included important hospital announcements and general public health messages. It was also suggested that phone calls could be used to screen patients to determine whether they should come for follow up visits or not – for example, a phone call could be used to follow up with a mother for the 3-day postnatal visit to prevent her from making an unnecessary trip to the clinic if everything seemed to be going well.

4.C.6: More staff opinions regarding the use of mobile phones in healthcare:

Another set of five questions were asked to determine respondents' opinions regarding whether they would be willing to use phone calls/text messaging to communicate with their patients; whether they felt that mobile phone technology could improve healthcare and health outcomes; whether incorporation of mobile phone technology is cost effective and would save time. Their responses to all these questions are summarized on table 10 below, and discussed in more detail under various sub-headings (which are the actual questions that the respondents addressed on their questionnaires).

Table 10: Staff opinions regarding mobile phone communication in healthcare:

Response		S. agree	Agree	Neutral	Disagree	S. disag
Question:		%	%	%	%	%
1	Willing to Use	25	50	8	10	7
2	Improve care	35	36	10	12	8
3	Cost-effective	15	23	24	30	8
4	Save time	28	48	6	13	4
5	Improve outcomes	30	51	7	9	3

[Question 1] *"I will be willing to use a system with which I could communicate with patients via cell phone (SMS or phone call) (i.e. the creation of a cell phone communication network is acceptable to me)."*

As shown on figure 13 below, most staff members (75%) indicated willingness to use a mobile phone system (mHealth) to enhance communication patients. The reasons they cited for willingness to use mHealth included its ubiquity among patients, its potential to improve adherence to medication regimens and appointments, and its ease of use. Most respondents also felt that mobile phone communication could save patients time and money by reducing unnecessary visits to clinics, and also shorten queues in clinic.

The respondents that were unwilling to use mHealth indicated a preference for one-on-one communication. Some also felt that they were short-staffed and over-worked, and therefore did not want an additional responsibility. Others felt that patient limitations such as illiteracy and language barriers could limit the effectiveness of such an intervention.

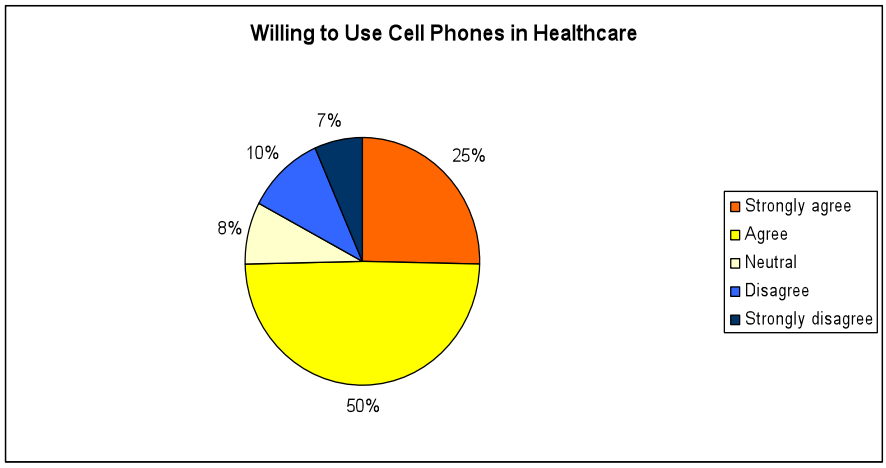


Figure 13: Staff willingness to use mHealth: 75% were willing

[Question 2] *Communicating with patients via SMS or phone call would improve the quality of care and services they get.*

Most of the healthcare staff (70%) felt that mHealth would improve the quality of care and services that patients would obtain (see figure 14 below). They felt that the quality of healthcare and services would be improved because there would be better adherence to medication regimens and appointments if reminders were sent to patients. mHealth would also lead to reduced clinic visits and therefore shorter queues and more efficient care in clinics. They also felt that it would speed up communication and lead to timelier interventions. The respondents that felt mHealth would not improve patient care thought that it compromises the doctor:patient relationship and reduces rapport with patients. Additionally, they felt that it would be more difficult to maintain confidentiality of information, especially with text messaging.

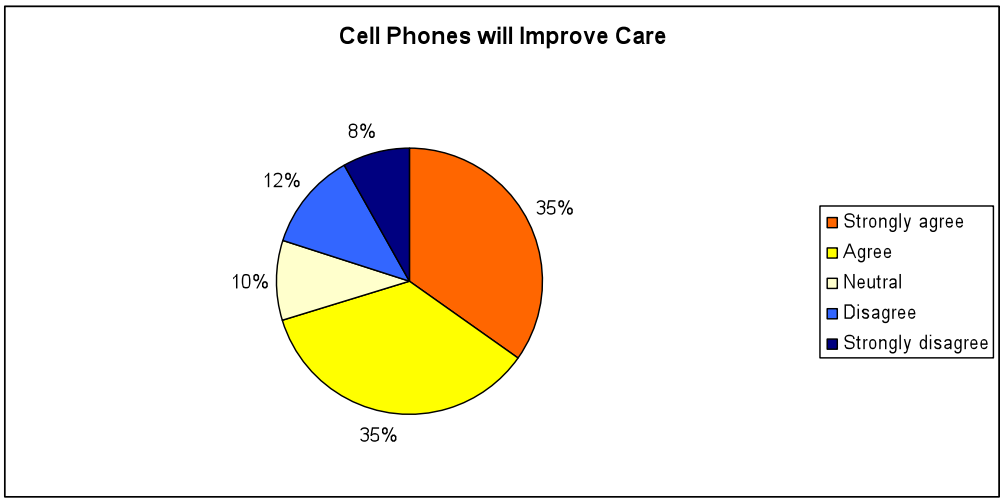


Figure 14: 70% of staff thought mHealth could improve health care

[Question 3] *A system for communicating with patients on their cell phones will be cost-effective:*

Only 38% of healthcare staff felt that mHealth is cost-effective (see figure 15 below). Those that felt it was a cost-effective cited text messaging as a cheap, effective communication. Most of the respondents thought it was too expensive for clinics and hospitals to call patients routinely, especially given the expensive telecommunications costs in South Africa. They also felt that given how short-staffed they are, staff would have to be hired to handle phone calls/ text messaging, increasing hospital costs.

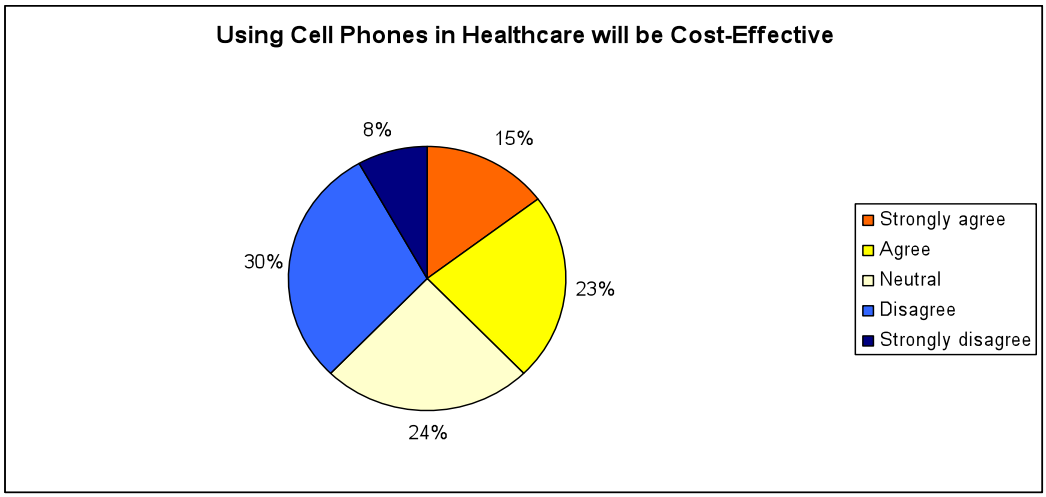


Figure 15: Only 38% of staff thought that mHealth is cost-effective

Many respondents who felt the mHealth is cost-effective method cited that it would save patients time and money, since it would eliminate unnecessary trips to hospitals and clinics. They also felt that the benefits of increased health information, and behavioral changes such as better adherence to medication regimens outweighed the costs.

[Question 4] *A system for communicating with patients on their cell phones will be save time:*

Majority of the healthcare staff (77%) felt that communicating with patients on their mobile phones would save time (see figure 16). They felt that it would save the patients' time most significantly, since they would not have to go to clinic for simple reasons such as obtaining test results. It would also reduce queues in hospitals, and reduce the time spent triaging patients in clinics and hospitals. It would save field workers time, since they would call patients instead of always traveling to their homes for home home-visits.

Those respondents that felt that mHealth will not save time claimed that they are already overworked and have no time to call or send text messages to patients.

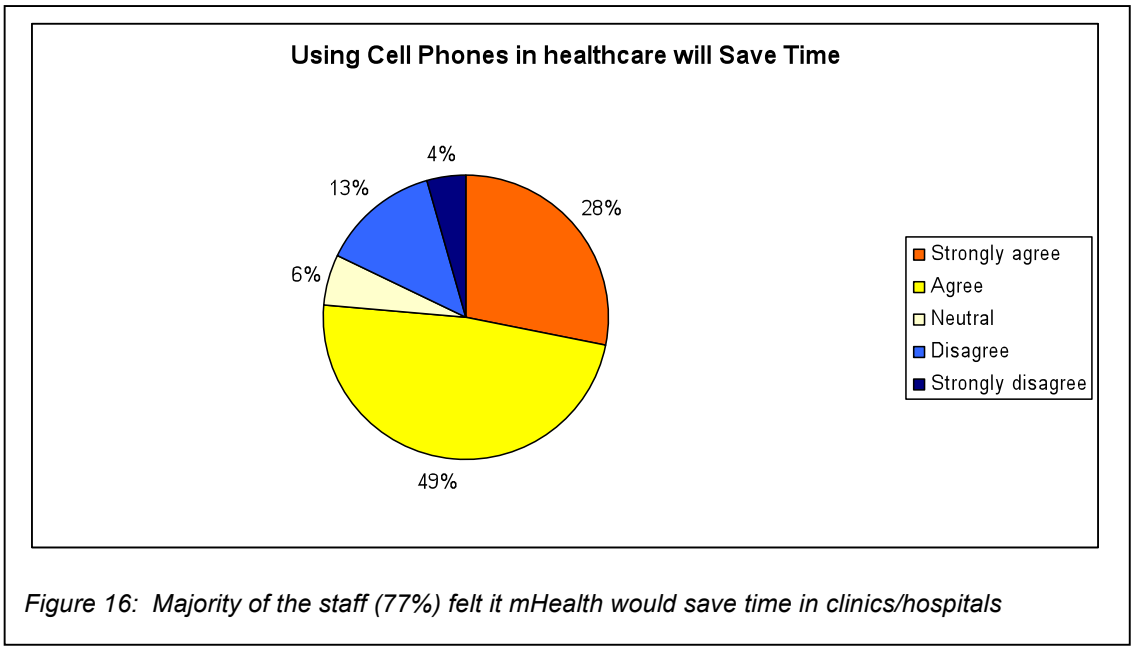


Figure 16: Majority of the staff (77%) felt it mHealth would save time in clinics/hospitals

[Question 5] *A system for communicating with patients on their cell phones, will improve outcomes (e.g. rates of attendance).*

A majority of the healthcare staff (81%) felt that mHealth would improve outcomes such as rates of clinical attendance, or rates of adherence to medications. They were aware that many poor patient outcomes are due to miscommunication/ inadequate communication, and therefore felt that enhanced communication with mobile phone technology would greatly improve outcomes by better informing and educating patients (see figure 17 below).

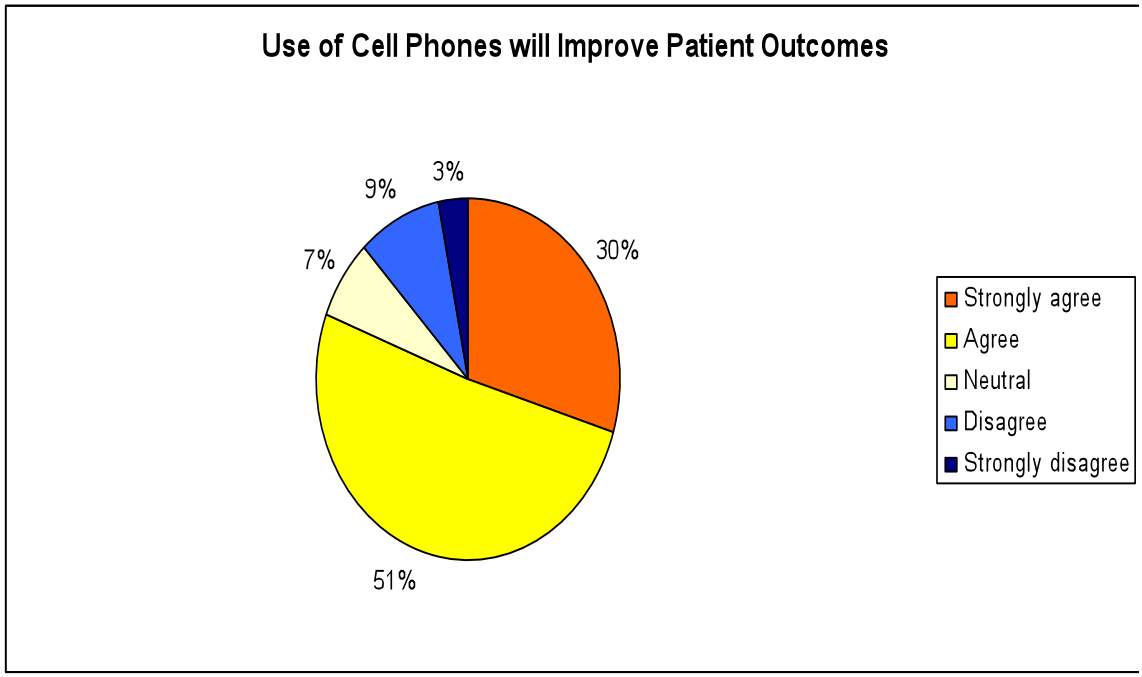


Figure 17: Majority of the staff (81%) felt it mHealth could improve patient outcomes

4.C.7: Staff ideas for designing an improved communication system:

In response to the open-ended question: "*If you had to design a communication system to facilitate better communication with your patients, what would it entail?"* staff members gave various suggestions on ways in which their communication in healthcare could be enhanced. The general themes in their answers were as follows:

- Languages: Designing a system that allowed multiple languages to be used in communication – for example, sending text messages in ethnic languages and hiring support staff who speak various languages.

- Simplicity: Information delivered to the patients should be concise, clear, and simple to understand; yet informative and effective.

- Those who mentioned the use of mHealth felt that the most appropriate types of communication to use were phone calls and text messages, given their ease of use among most people. A few respondents also suggested the use of emails (mainly in inter-provider communication); and also multi-media messaging – e.g. sending pictures/ short video clips.

- Communication should be two-way, and therefore toll-free numbers should be incorporated to the system to allow patients to contact providers with patients directly at no cost to patients. Each unit should also have a phone number to which patients can text questions/concerns

- Computerization of the system: To enable databases with relevant patient information to be created so as to prevent loss of patient information and to enable easier data access. A computerized system to enable easier dissemination of mass messages to recipients.

- Wide range of applications: In addition to appointment/medication reminders, reporting test results to patients, and sending them educational messages, it was felt that healthcare workers could use mobile phones in the field for more complex data collection.

- Resources: There should be additional staff hired to handle these new communication methods and thereby not increase the workload of the existing staff.

Other issues that were raised included patient confidentiality. It was emphasized that efforts should be made to protect patient privacy, especially given that many patients share the mobile phones with family members. Additionally, it was felt that the government should liaise with mobile phone providers to negotiate cheaper rates for phone calls and text messages.

Sub-project C: Randomized Controlled Trial

The results for subproject C – the randomized controlled trial, which aimed at determining whether an intervention using phone calls and text messages to remind patients to attend their 3-day postnatal visit – will be presented under the sub-headings listed below. The primary outcome for this study was attendance rates at clinic (4.C.3).

4.C.1: Patient recruitment and characteristics

4.C.2: Patterns and preferences of mobile phone use

4.C.3: Postnatal clinic attendance

4.C.4: Reasons for non-attendance

4.C.5: Satisfaction with reminder

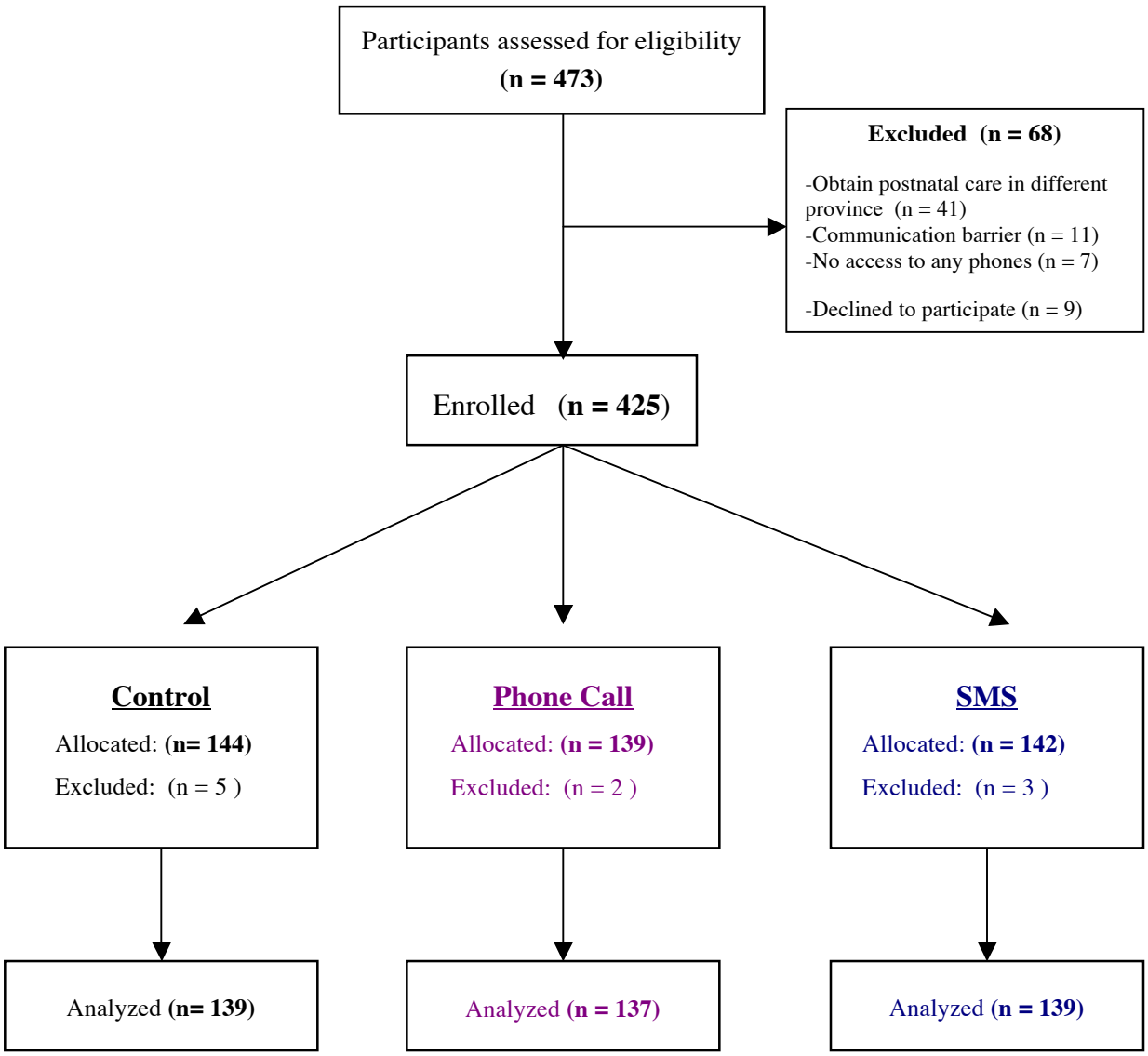
4.C.6: Cost analysis

4.C.7: Other lessons/observations from RCT

4.C.1: Patient recruitment and Patient Characteristics:

The participants for the randomized controlled trial were recruited as demonstrated on figure 18 below. A total of 473 mothers who had recently delivered babies by uncomplicated vaginal delivery were approached to participate in the study. Sixty eight of them were not eligible because 41 mothers indicated that they planned to obtain their postnatal care in a different province/ in a clinic not included in the study; 11 mothers could not speak any English (and there was no healthcare worker readily available to serve as an interpreter); 7 mothers indicated that they did not have ready access to any cell phones; and 9 mothers declined to participate in the study.

Figure 18: Consort Diagram showing patient enrollment in RCT:



Reasons for exclusions:

-Control: (2) wrong numbers given; no clinic data/ways to trace attendance
(1) patient died in hospital shortly after delivery
(2) patient had prolonged hospitalizations, beyond day 3 of their visits.

-Call (1) premature baby that died in hospital on day 3. Mother still in hospital and didn't go for her visit
(1) wrong number given. Unable to reach patient

-SMS (1) invalid phone number provided
(2) with prolonged hospitalizations (one of these due to heavy post-partum hemorrhage)

Of the mothers approached for the study, 425 of them met the inclusion criteria. They were assigned into groups as follows: Control group –144, Phone call group –139, and SMS group –142 participants. Ten of the 425 subjects were excluded from the final analysis because of the following reasons: three invalid phone numbers provided; one patient death; five prolonged admissions that extended past day three. Thus, the remaining 415 participants were divided as follows: 139, 137 and 137 in the control, phone call and SMS groups respectively.

The characteristics of the final 415 participants in the RCT whose data was analyzed is displayed on table 11 below. About two thirds of them (67.7%) delivered their babies at Mamelodi district hospital, while approximately one third (32.3%) delivered their babies at Stanza Bopape Community Health Center.

Table 11: Characteristics of 415 participants in RCT:

Characteristics		**N (%)**
Age (mean ± SD), range (15-44)		26 ± 6.1
Education Level		
	Some high school and less	219 (52.8)
	High school graduate & above	196 (47.2)
Employment		
	Employed	116 (28)
	Unemployed	299 (72)
Hospital of Baby Delivery		
	Mamelodi Hospital	281 (67.7)
	Stanza Bopape	134 (32.3)
Preferred Language		
	English	239 (57.6)
	SiPedi	44 (10.6)
	Sotho	38 (9.2)
	IsiZulu	37 (8.9)
	Tsonga	20 (4.8)

	Others	37 (8.9)

The participants ranged in age from 15 to 44 years in age, with a mean age of 26 years. Slightly less than half (47.2%) of them reported that they had successfully finished high school, and about 13% of them were pursuing/ had completed some form of tertiary education. About 28% of the participants were employed and 58% listed English as their language of preference.

Table 12 below compares certain variables across the different RCT group. Note that they were distributed fairly evenly, and therefore there was no significant statistical difference between the participants in different groups in terms of age, employment level, and education level.

Table 12: Comparing characteristics of 415 patients in RCT by group:

Characteristics	**Control**	**Call**	**SMS**	**p**
	N (%)	N (%)	N (%)	
1) Number of patients	139	137	139	-
2) Age (mean ± SD)	25.7 ± 5.8	25.8 ± 6.2	26.6 ± 6.4	-
3) Employed	23%	28.5%	32.4%	0.22
4) Education > High school	50.4%	44.6%	46.8%	0.63
5) Own personal cell phone	81.8%	79.1%	87.8%	0.15

4.C.2: Patterns and preferences of mobile phone use

The patients recruited for the RCT responded to a questionnaire similar to the one in sub-project A that collected information on patterns and preferences of cell phone use among mothers. Regarding access to phones, 46/415 patients (11.1%) reported that they had a landline phone in their home. All of them had access to mobile phones; and 344/415 mothers (83 %) owned their own personal mobile phones. In sub-

project A, a similar percentage of respondents from Gauteng (81%) owned personal mobile phones.

Regarding functions of mobile phone used, like the respondents in sub-project A, most of the mothers in the RCT used their phones to make and receive calls (95% and 97% of mothers respectively); to send and receive text messages (84% and 90% of mothers respectively); and to check voicemail (57%). Very few 24/415 (5.8%) reported using their phones to access the internet. Most patients 389/415 (94%) reported using their mobile phones at least daily. The other 6% used their phones at least once a week.

When asked what they felt regarding communication with healthcare providers on their mobile phones, 383/415 respondents (92%) in the RCT were positive, 3% were neutral and 5% were negative towards it (see figure 19 below). In comparison, 86% of the respondents from Gauteng in sub-project A were positive towards using mobile phones in healthcare communication, while 5% were neutral and 9% were negative. There was no statistically significant difference in their views (p = 0.19).

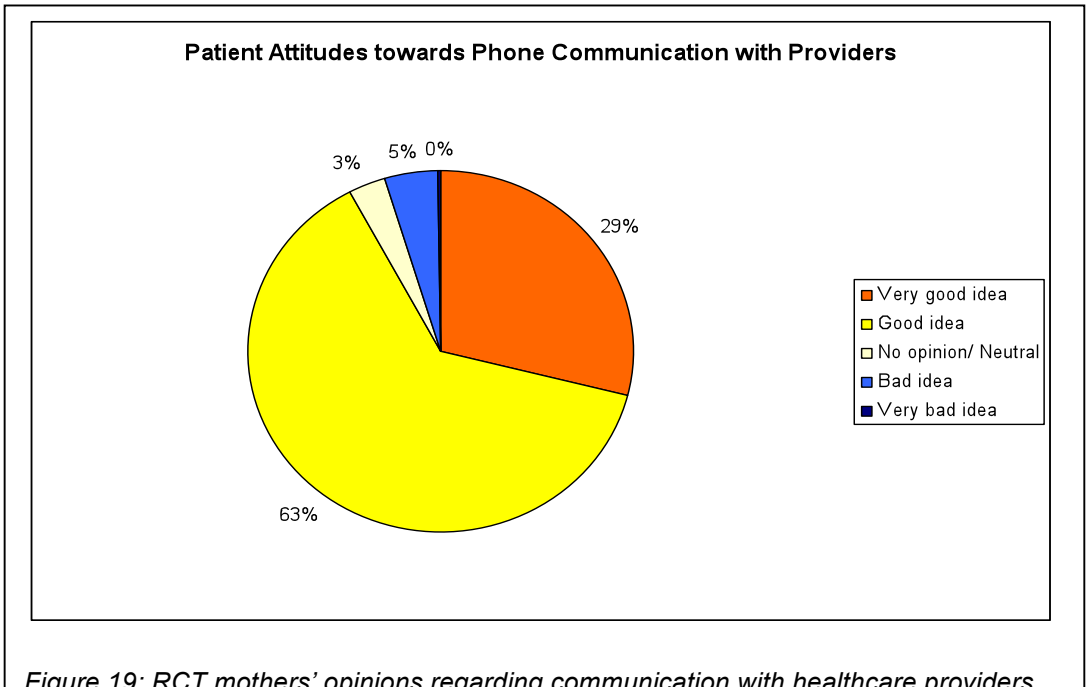


Figure 19: RCT mothers' opinions regarding communication with healthcare providers

When asked what mode of communication they would prefer (in terms of the hospital contacting patients), 26% of respondents reported a preference for phone calls only, while 57% of them were open to both phone calls and text messages and 18% preferred text messages only (see figure 20 below). In contrast, in the questionnaire administered to mothers attending antenatal clinics in Gauteng in sub-project A, there was a statistically significant difference in preferences ($p < 0.001$): 45% of respondents preferred phone calls only, 41% of were open to both phone calls and text messages, and 15% preferred text messages only.

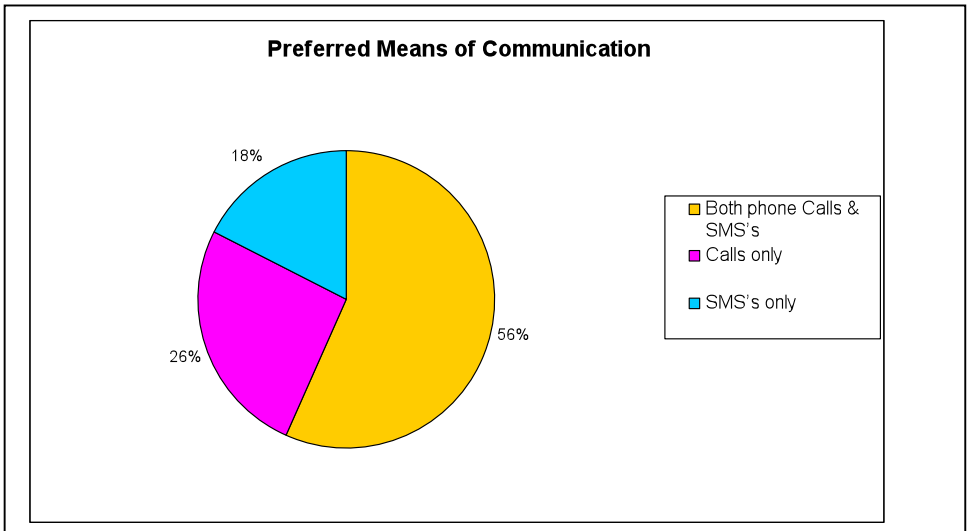


Figure 20: RCT mothers' preferred modes of communication with healthcare

Regarding type of information to be communicated to patients by providers, most participants in the RCT were open to receiving appointment reminders (91%), educational messages (82%), medication reminders (77%), and results of blood tests (75%) from providers. A similar number of participants in sub-project A (87%) were open to receiving appointment reminders via mobile phones. Additionally, just as in

sub-project A, appointment reminders were the most preferred type of information to communicate via mobile phones, followed by educational messages, medication reminders, and blood test results. However, there were less participants in sub-project A who were willing to use mobile phones for educational messages, medication reminders, and blood test results (72%, 64% and 53% of respondents respectively). These differences are statistically significant ($p < 0.001$).

Regarding best times to contact patients, responses of participants in the RCT were similar to those of respondents in sub-project A, with most patients preferring calls during business hours. Similarly, when respondents were asked what methods they would use to communicate their concerns to the hospital, as in sub-project A, phone calls were preferred to SMSes and "Please call me" messages.

Finally, just as in sub-project A, English was the preferred language of communication in most respondents in the RCT (58% of respondents). Although about 40% of the participants did not cite English as their preferred language of communication, most of them can use it as a language. About 93% of the participants reported that their level of speaking English was good or very good; while 95% of them reported that their level of reading/writing English was good or very good. Other local languages preferred by respondents in the RCT included isiZulu, SeSotho, SiSwati and SiPedi.

4.C.3: Postnatal Clinic Attendance

Attendance rates at postnatal clinics during the 3-day visit were as follows for the three groups in the study: Control – 63 out of 139 participants (45.3%), Call group – 99 out of 137 participants (72.3%), and SMS group – 113 out of 137 participants (81.3%). The absolute difference in attendance between the call and control groups of 27%. This was a statistically significant difference ($p < 0.001$). The absolute difference in attendance between the SMS and control group was 36%, and it was also statistically significant ($p < 0.001$). There was an absolute difference of 9% between attendance rates of the phone call and SMS groups. However, this difference was not statistically significant ($p = 0.075$). See figure 21 below.

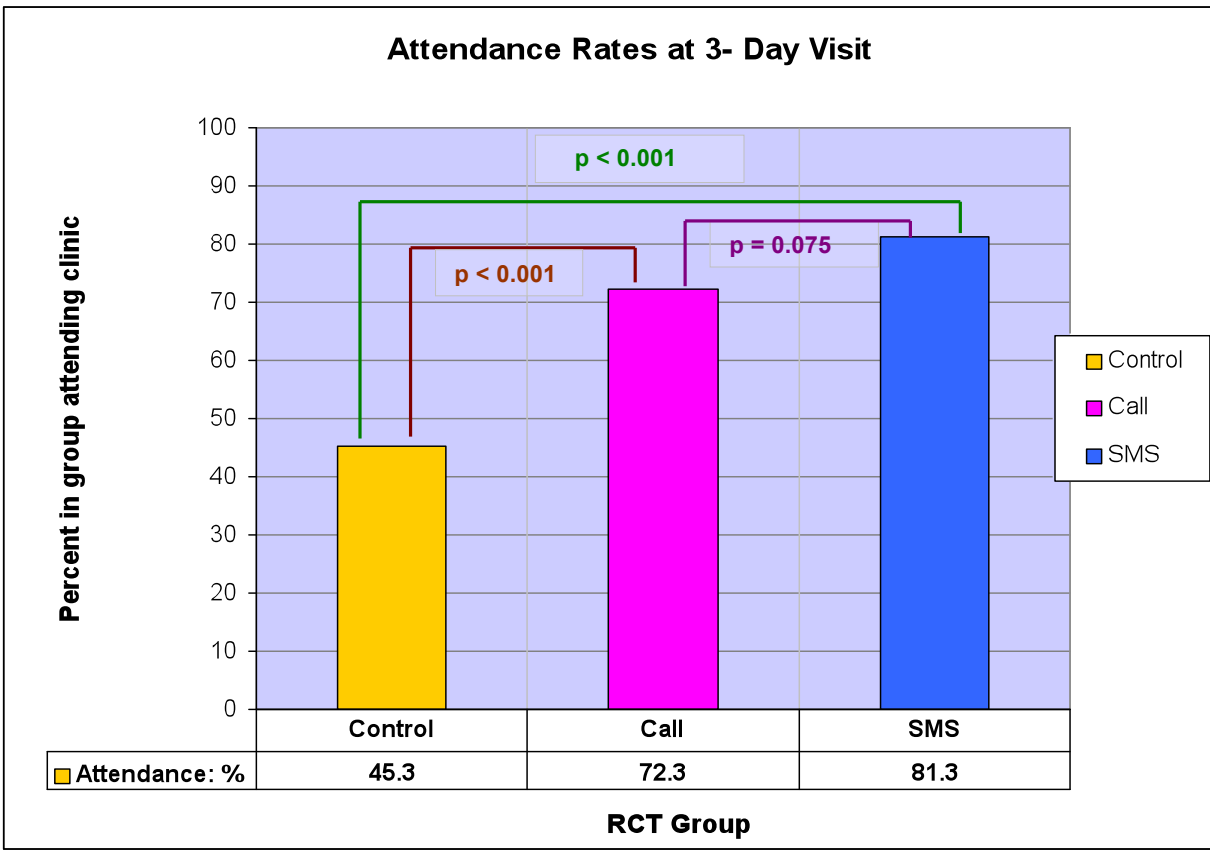


Figure 21: Attendance rates at postnatal clinics among mothers in different RCT groups

The odds ratio of participants in the SMS group attending their 3-day visit was 5.68 (with a 95% CI of 3.27 – 9.87) when compared to controls; while the odds ratio of participants in the phone call group attending their 3-day postnatal visit was 3.14 (with a 95% CI of 1.90 - 5.12) when compared to the control group. Comparing the SMS and phone call group, the odds ratio of a participant in the SMS group attending the 3-day visit over a participant in the phone call group was 1.8 with (with a 95% CI of 1.01 – 3.2), suggesting that SMS'es were better reminders that phone calls.

To determine whether patient variables such as age group, education level, employment level and language preference affected attendance rates at clinics, analyses were run on SPSS using crosstabs and chi squares. It was found that there were no associations between the above patient variables and 3-day visit attendance rates at clinic.

To determine whether other hospital or clinic-related factors such as: clinic where antenatal/postnatal care is provided and hospital where patient was recruited; analyses were also run to detect associations. The findings were that the clinics where the participants received antenatal care/planned to obtain postnatal care did not influence their rates of attending their 3-day visit. However, there was an association with the site of delivery: 176 out of 281 mothers (62.6%) who gave birth at Mamelodi Hospital attended their 3-day visit; while 99 out of 134 mothers (73.9%) who gave birth at Stanza Bopape CHC attended the 3-day visit. ($p = 0.023$). This difference between sites was persistent among all the study groups (see figure 22). This implies that there must be a difference in counseling/ patient education/ some other factor at Stanza Bopape that makes mothers more likely to return for their 3-day visit.

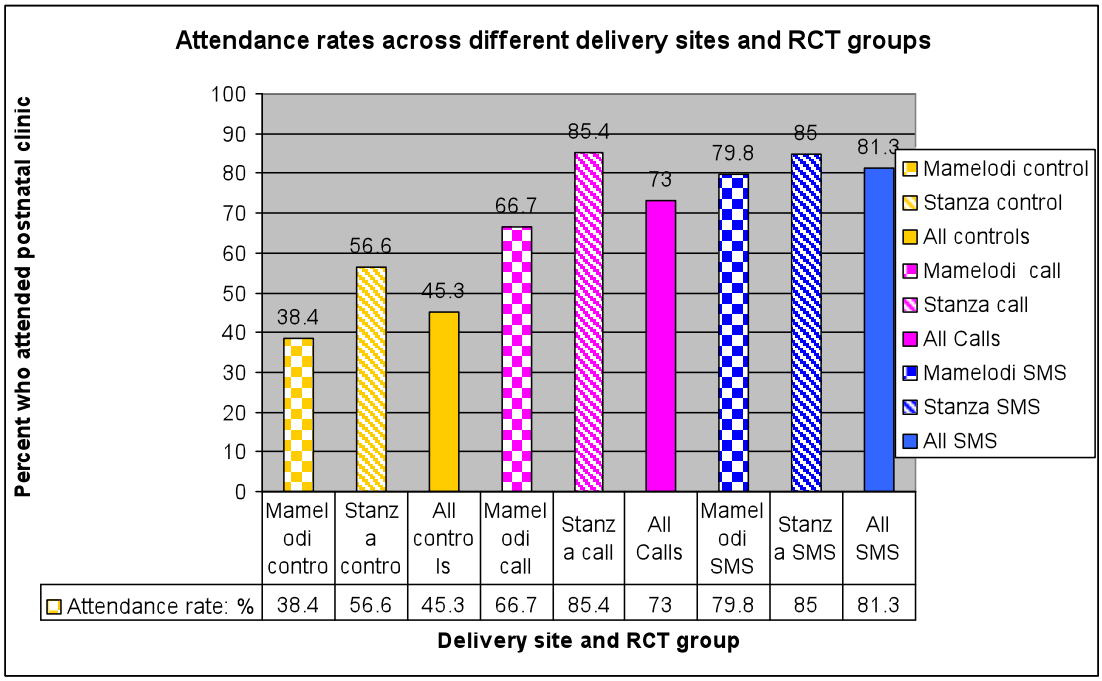


Figure 22: Effect of site of delivery on postnatal clinic attendance rates

Finally, to control for factors that may have affected attendance rates such as age, site of delivery and education level, a multivariable regression model was run to determine whether these factors affected attendance rates. The model showed that there was a still a statistically significant difference in attendance rates between the control group and intervention groups.

Timing of 3-Day visit:

Ideally, mothers should attend their 3-day visit on day 3 after delivery (or day 4, if day 3 happens to be on a Sunday). Among the mothers who attended their 3-day visit, the average number of days after birth was similar across all groups: 3.9 in the control

group, 3.9 in the call group and 4 in the SMS group. The reminders therefore seem to have had no effect on the timing of the 3-day visit.

4.C.4: Reasons for Non-Attendance

The participants mentioned these reasons for not attending their 3-day visits (see figure 19 below)

- Forgot to go /unaware of date (42)
- Feeling weak/ unwell/ very tired (25)
- Transportation issues (12)
- Cultural issues (12)
- Felt fine/ felt it was unnecessary (11)
- Was too busy/occupied to go (8)
- Out of town (8)
- Other (3)
- No explanation shared (14)

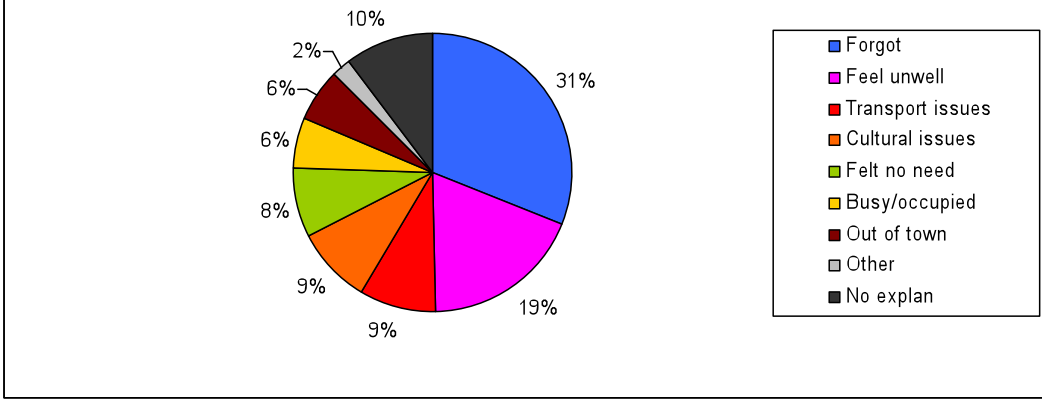


Figure 19: Reasons for not attending clinic

4.C.5: Satisfaction with Reminders

Another major outcome measure studied was satisfaction of participants with their SMS or phone call reminders. To obtain satisfaction data, 248 mothers were interviewed by phone: 122 in the call group and 126 in the SMS group. In the call group, a total of 108 out of 122 participants (88.5%) indicated satisfaction with their reminders; while in the SMS group, a total of 108/126 participants (85.7%) were therefore satisfied with their reminders. There was no statistically significant difference in the satisfaction of participants with their reminders across groups (see table 13 below).

Table 13: Satisfaction of Patients with Reminders

Characteristics		**Call**	**SMS**	**Total**
Satisfaction with reminders		N= 122	N= 126	N = 248
	Very satisfied	35 (28.7)	46 (36.5)	81 (32.7)
	Satisfied	73 (59.8)	62 (49.2)	135 (54.4)
	Neutral	11 (9)	14 (11.1)	25 (10.1)
	Dissatisfied	3 (2.5)	2 (1.6)	5 (2)
	Very dissatisfied	0 (0)	2 (1.6)	2 (0.8)

Reasons for Satisfaction Responses:

Most participants (87%) reported being “satisfied” or “very satisfied” with their SMS or phone call reminders to attend their 3-day visits. Many of them felt it was a “good idea” and a “useful reminder;” and about a quarter of them reported that they would have forgotten about the visit without the reminder. Some participants who received SMSes mentioned they liked the fact that they could reference the message

several times. A few participants mentioned that it indicated to them that healthcare staff cared for their well-being.

Twenty five participants felt neutral regarding the reminders, and 21 gave reasons for their responses as follow. Six claimed they did not receive the SMSes on their phones, and one forgot what about the reminder despite getting and phone call. Five respondents felt the reminders were unnecessary since they did not affect their plans regarding whether to go to clinic or not. Four claimed that the messages were not transmitted to them since they did not own their personal phones. Two would have preferred a phone call to an SMS, while one felt that a phone call was invasive and would have preferred a text message. Finally, two respondents would have preferred the reminders in local languages, and not English.

Two participants reported being "very dissatisfied" with SMS reminders. One of the two just did not want a reminder, while the other claimed that her phone screen has technical issues and is blank, and therefore she should have been called (as she specified).Two other participants reported being "dissatisfied" with their SMS reminders: one of them claimed she did not receive the reminder while the other reported that her baby had just died and the SMS seemed insensitive to her loss.

Three participants reported being "dissatisfied" with their phone call reminders. Two of these three cited language barrier as an issue, since they do not speak good English and could not understand the call. Another participant reported that the call made her feel pressured to go to clinic, yet she did not want to attend it due to cultural reasons

4.C.5: Cost Analysis

It was significantly cheaper to send patients reminders using SMS versus phone calls. The average costs of sending an SMS was 0.35 rands (equivalent of 4.4 U.S. cents) per SMS.[‡‡] 139 SMSes were sent to patients, amounting to a total cost of ZAR 48.65 (U.S. $6.1). Although there were SMS templates to aid with the speed of manually entering them, it took about 1 minute to send each SMS.

Calls were more expensive than SMSes. 137 calls were made costing R 126.25 (US $15.8), leading to an average cost of R 0.92 (11.5 cents) per phone call. These calls were made in the evening to avoid higher daytime phone tariffs). Had the calls been made during business hours (the times patients indicated as their most preferred times to receive calls), they would have tripled in cost, amounting to about R 2.76 (U.S. $ 0.34) per patient. Regarding time spent on calls, the average call was about 41 seconds in length. However, an average log of about 65 seconds per call was recorded (factoring the time it took to dial the number and repeat attempts to make calls).

SMSes were therefore more cost-effective than phone calls in this study, since it cost almost three times more to make phone calls than to send text messages. The time it took to make calls/ send text messages was similar in this study.

4.C.6: Other observations/ lessons learned from the RCT

1) Experience during the 3-day visit:

Most mothers reported that when they attended their 3-day postnatal visits, both they and their infants were checked. For the most part, the visits included a history and

[‡‡] Using the average 2009 exchange rate of eight South African rands = one U.S. dollar.

a quick physician exam to determine how the mothers and babies were doing. Thirty seven participants (13%) reported that only their babies were examined during the 3-day visit.[§§] Most of participants reported that no complications were detected during their visits. A few patients complained that the queues in the postnatal clinics were long and it took them a long while to be seen. Others (who were excluded from the main analysis because they attended postnatal clinics outside the greater Mamelodi area) reported that they were scolded for returning for their postnatal visits "too early" (prior to the six-week visit). Two mothers who received postnatal care in other provinces mentioned that the nurses in those clinics (which do not routinely check mothers during the 3-day visit) were unsure about what to look for during that visit.[***]

It was also observed by the primary researcher that there was variation in the quality of care provided during the three-day visit in different postnatal clinics. The clinic that seemed to offer the best care was the Stanza Bopape I postnatal clinic. In this clinic, standard documentation (the postnatal card) was used to guide the visit and to documents the mother and baby's progress. The nurses there therefore carried out more thorough and complete histories and physical exams since they had a template to guide them. In the other clinics, it was simply documented in records that the mothers and babies attended their 3-day visit and it was also recorded whether any complications

[§§] Of these 37, majority visited two particular postnatal clinics that did not routinely examine mothers during their 3-day visit prior to the start of this project.

[***] Note that while the 3-day visit is highly recommended for most mothers and babies in South Africa, not all clinics routinely see mothers at the 3-day postnatal visit. Efforts are currently being undertaken to encourage healthcare staff to routinely see mothers and infants during the 3-day visits. Efforts are also being undertaken to train nurses to effectively screen mothers and babies for complications during the –day visit.

were detected. In one clinic, only the infant's progress was recorded in the chart. In this particular clinic, all infants received a physical exam; however, only a fifth of mothers also received a physical exam. There was therefore variation in the postnatal care received in different clinics.

2) Complications detected during the 3-day visit:

There were 20 complications detected in patients who went for their 3-day visit. Given that 275 patients in our study attended clinics, the complication rate in our study was 7.3%. The complications detected in clinic were: Infections in 6 patients (three cord infections in infants, two episiotomy site infections and foul vaginal discharge in another mother). Hypertension was detected in three mothers. Three other mothers had breast tenderness/ inflammation. Two babies had rashes. One baby was anemic; and another one had jaundice. Another one had a cough. In three cases, the complications were not specified.

3) Difficulty of Patient Follow Up

It was relatively easy to reach the participants in the phone call group to remind them to attend their three-day visits. About 70% of them were reached during the first attempt, and the rest were reached during the next two attempts.

However, it was frustrating to reach patients for follow up one to three weeks after delivery to determine whether they went to clinic; what their experiences at the visits were like, and also to determine satisfaction with reminders. For the follow up calls, only 44% of the participants called picked up their phone during the first call

attempt. Another 40% of patients picked up their phones during the second call attempt. About 20% of patients needed to be called three or more times for follow up. Twenty four patients (5.8% of total patients) were not reached at all (up to six calls).

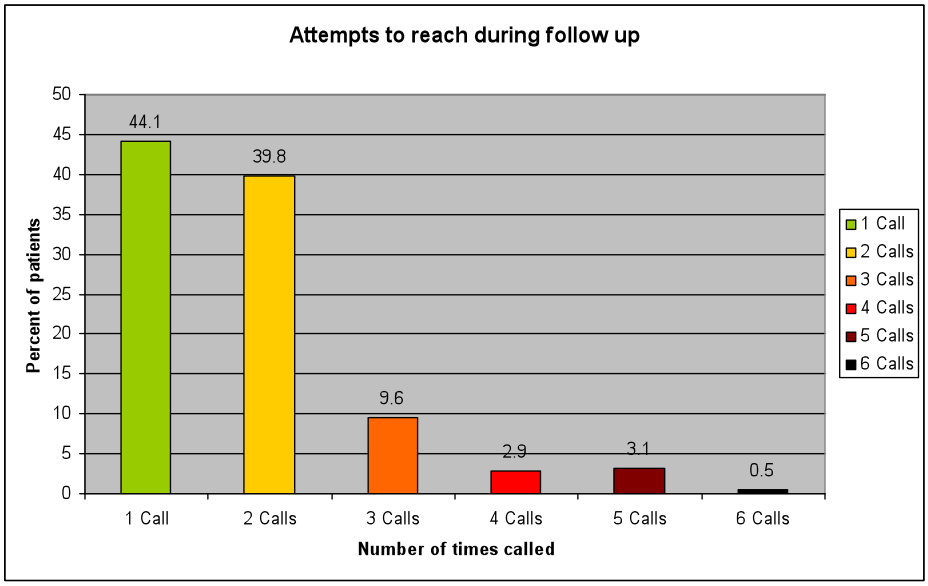


Figure 18: Number of attempts to call patients during follow up.

5. DISCUSSION:

The discussion is sub-divided according to the corresponding sub-projects. The discussions of the sub-projects are followed by limitations of the study and a summary of the main conclusions from the study.

5.1: Sub-Project A: Patterns and Preferences of Mobile Phone Use

- Mobile Phone Access & Frequency of Use:

Mobile phones are ubiquitous in South Africa. Almost all of the respondents surveyed (98%) had access to mobile phones – even those who were unemployed or who live housing without electricity, compared to only 11% who had access to landlines. The results of this project are consistent with the findings of a study by the Vodacom and the United Nations in South Africa in 2005, which found that 96% of the population they surveyed had mobile phone access.[23,74] Given increasing uptake of mobile phones around the world, and especially in Africa, it is expected that the penetrance of mobile phones in South Africa may soon approach 100%!

The frequency of mobile phone use in South Africa is high: 74-94% of respondents in our study reported daily use of cell phones (despite high unemployment rates). This is consistent with the study by Esselar et al that found that majority of South African respondents used their phones daily and were willing to re-allocate their limited resources in order to have mobile phones and maintain connectivity.[23] Given the ubiquity of mobile phone access in South Africa, the high frequencies of mobile phone use and its great importance in their lives, there is great potential to design programs

and interventions that can be used for greater social change, in healthcare and other sectors.[76]

While mobile phones are personal devices that are not frequently shared in the developed world, in South Africa, they are resources that are sometimes shared with family members and friends. Despite high access to mobile phones, only about 81% of the participants in our study had their own personal mobile phones, and the rest shared phones with family members. It is likely that some of the respondents who owned personal mobile phones shared them with other people who did not have phones. In the design of mHealth interventions, it should be considered mobile phones are sometimes shared/ communal devises, and therefore extra measures need to be implemented to ensure privacy and confidentiality of information.

- Factors affecting mobile phone use:

In our study, factors affecting mobile phone ownership and use among respondents included employment, education level and age. Respondents who were employed, had completed high school and were between 22 – 29 years of age were more likely to use phones more frequently and for a wider range of functions. These factors are similar to those that affected mobile phone access and use in the study by Luo et al in Singapore. [44]

Age not only affects ownership and frequency of mobile phone use, but it also affects the role/ importance of mobile phones in peoples' lives. According to Lefebvre (2010), mobile phone users can be classified in three groups: (i) The Cellular generation, aged 18 – 24 years who use phones as a part of their every day lives; (ii)

The Transitional generation, aged 25 – 34 years who experienced mobile phones in their teens/early adult years and use phones frequently; and (iii) the Adult adopters (aged 35 and over): who were not exposed to mobile phones till late and only use it for minimum communicative functions.[40] The findings of our study were consistent with global trends. Younger respondents aged 29 and under were more likely to use their mobile phones for text messaging than older respondents. Additionally, they were more likely to use phones for other functions such as: internet access, photography, games, instant messaging/ MXit, radios, alarm clocks, etc. Better-educated participants also tended to use their phones more frequently, and for a wider range of functions. It was also found that among the young who used their phones for varied purposes, majority resided in urban areas. These age-related differences should be borne in mind when designing mobile phone interventions for populations in different age-groups. Several studies in the U.S. have taken advantage of the high rates of mobile phone use among youth in designing interventions that target them.[12,25,44,84]

Although a few younger people in South Africa reported using their mobile phones for functions beyond calls/text messages, their numbers were low. It is expected that as mobile phones with greater capabilities such as cameras and internet-friendly browsers get cheaper, more South Africans will use these functions on their phones. Use of advanced mobile phone functions such as multi-media messaging can enhance the scope of healthcare provision in patients in future – for example, patients can monitor the progress of certain conditions such as various rashes or wounds by taking pictures of them on using their mobile phones and transmitting these to their physicians, as is being currently done in Uganda with the African Teledermatology project.[74]

- Rural / Urban differences in mobile phone use:

Interestingly, there was no difference in levels of access, and basic functions used on mobile phones between urban areas with more resources and higher employment rates (Gauteng) and rural areas (Mpumalanga and Limpopo). This finding is consistent with findings in the U.S., in which levels of access to mobile phones among respondents in inner cities/lower income neighborhoods were the same (and in some cases even higher) as levels of access to mobile phones among middle-class members of society. [3,11]

Language of preference seemed to be the biggest difference between mothers surveyed across the different provinces. In Gauteng, English spoken most commonly, while in the rural areas, local languages dominated. Language must therefore be considered in the design of any mobile phone intervention in South Africa. Given the diversity of languages spoken in the country, adapting interventions to local languages may pose a challenge.

- Under-utilization of mHealth in South Africa

Mobile phones are currently under-utilized in communicating with patients. Less than 1% of the patients reported ever being contacted on their phones by healthcare providers. Yet, patients are highly receptive towards healthcare providers communicating with them via mobile phones: given that 86% felt that felt that it was acceptable to use mobile phones in healthcare communication. South Africa is lagging behind other developing countries such as India in terms of incorporating mHealth to practice. In a low-income South Indian study group, a high percentage of patients (66%) reported using mobile phones to maintain contact with their providers. [66] There is

therefore a needs gap in South Africa, which hopefully will be addressed in future years as more mobile phone applications and interventions are developed for social good change.

- Implementing a simple mHealth intervention in South Africa

The respondents in our study felt that the most appropriate types of information that should be communicated to patients on their mobile phones included: appointment reminders, medication reminders, educational messages, and test results. These types of communication – especially appointment and medication reminders – have been communicated to patients via text messages in several studies with good results (in terms of improvement of outcome and general satisfaction with these systems).[4,13,24-6,29,38] Increasingly, there has been a trend of using mobile phone-based interventions to specifically target HIV-positive populations. Most of these interventions target adherence to HAART regimens and prevention of mother-to-child transmission of HIV, such as the studies by Dao (2007),[13] Lester (2009),[42] Shet (2009),[66] and Cell-Life in the Western Cape of South Africa.[58]

mHealth systems that primarily use text messages have the potential to be very successful in South Africa, given the simplicity of SMS-ing, widespread use of SMS, and ability to easily use text messages in appointment reminders, medication reminders, and educational messages. Text messages are cheap; additionally, SMS systems can be easily scaled up by linking phones to computer systems to enable bulk text messages to be sent. Hopefully, more studies/ interventions covering other aspects of HIV/AIDS care such as support groups, and specific education will be developed in South Africa and elsewhere.

5.2: Sub-Project B: Staff Views

- Inadequacies in current communication methods:

Our study also revealed that while there are many forms of communication used in the clinics/ hospitals outside the patient-provider encounter, the most commonly used posters, pamphlets, and in rural areas, health promoters who visited patients' homes. Most healthcare providers admitted that their current communication methods are insufficient due to several patient-related and systemic barriers. They suggested several innovative and practical ways in which patient-provider communication could be enhanced, including the incorporation of mobile phone technology to healthcare. They are a therefore huge resource that should be considered and incorporated into the decision-making process when attempting to design and implement a mHealth system.

- Healthcare staff and mHealth:

Mobile phone use is extremely high among healthcare staff, with almost all of them owning their personal mobile phones (98% ownership rate, compared to 83% in their patients) and over 95% of them reporting mobile phone use on a daily basis. Healthcare staff reported use of their mobile phones for a wider range of functions than their patients including internet access (43% in staff compared to ~3% in patients) and multi-media messaging. Given their more advanced use of mobile phones, it is likely that they are capable of easily adapting to a wide range of mHealth systems, from simple ones involving modalities such as text messaging to more complex ones.

There were similarities between what types of information both healthcare providers and patients felt would be most appropriate to communicate via phone calls or

text messages. In general, appointment reminders were the most acceptable type of information to disseminate via mobile phones among both patients and staff, followed by educational messages and medication reminders.

Despite their greater use of mobile phones, healthcare staff were not as enthusiastic as the patients regarding incorporating mobile phone technology to healthcare: 86% of patients indicated support for a mHealth system (with 57% of these indicating that mHealth was a "very good idea"), while 75% of staff indicated willingness to use mHealth (with only 33% of the willing staff indicating that they "strongly agreed" with the idea). There is therefore a gap between patients and providers in levels of acceptability of mHealth. One of the reasons why this gap exists could be that providers are more aware of the limited resources in the healthcare system. They are therefore concerned that a mHealth system might not be cost-effective and time-saving since it might add to their already busy workload.

Despite lower enthusiasm in healthcare staff regarding incorporating mHealth, they are still willing to try it out and believe it could improve outcome (81% of staff surveyed felt that mHealth could improve patient outcomes). More studies need to be successfully implemented for staff to be convinced that mHealth systems are effective and can time-saving as well as cost-effective. In the implementation of these systems, it is imperative that staff members are involved so that their input can be obtained. Additionally, staff involvement would increase their morale and enhance their chances of cooperating with mHealth systems.

5.3: Sub-Project C: Randomized Controlled Trial

- Non-Attendance at Clinics

Non-attendance at clinics is a universal problem experienced not only in maternal and child care, but also in other medical specialties. Low clinic attendance rates not only affect patient outcomes, but they also compromise the doctor-patient relationship, reduce the efficiency of the health system, and are costly.[38] For example, a study by Hogan et al in the U.K. in 2008 found that about 360 million pounds (equivalent to roughly half a billion US dollars) are wasted annually in the U.K. on missed appointments. [31] While there is no financial estimate on losses incurred in South Africa due to delayed or missed appointments at postnatal clinics, it is estimated that 30% of deaths in babies could be reduced if 90% of mothers attended their 3-day postnatal visit on time.[52, 53]

Reasons cited for non-attendance in other studies include patient factors such as forgetfulness, lack of time, other obligations, cultural beliefs, ignorance, and other personal reasons; as well as systemic factors such as clerical errors and long wait times. [24, 31, 38] These reasons are very similar to the reasons used by participants in our study.

- SMS reminders and attendance rates

In our randomized controlled trial, phone call and SMS reminders were very effective increasing attendance rates at the 3-day postnatal visit. The attendance rates of the control, phone call, and SMS groups were: 45.3%, 72.3% and 81.3% respectively. Our results are consistent with other studies in which text message reminders have significantly reduced failure to attend rates in clinics. For example, Downer et al

carried out a study in Australia in 2001 among 2,151 patients, in which the attendance rate was 85.9% in patients who received an SMS reminder, as opposed to 76.6% in controls. [20] In another study in Brazil by Da Costa et al (2010), text messages also improved attendance rates at clinic. The Da Costa study was a large-scale five-site study in that involved 29,000 appointments; in which 7,890 patients got appointment reminders. Non-attendance reduction rates for the clinics ranged from 0.82 – 14.49%;[14] compared to our study's non-attendance reduction rate of 36% between controls and subjects.

Studies in which SMS reminders did not seem to make an impact included the study by Fairhurst et al in the UK in 2008, which had a sample of 415 patients who were repeated non-attenders, 189 of whom received an SMS reminder to attend a clinic appointment. Their study did not show statistically significant reduction in non-attendance rates with SMS reminders in patients who persistently failed to attend appointments, suggesting that appointment reminders can only increase attendance rates to clinic to a limited degree; but other factors in patients' lives outside "forgetfulness" have to be addressed in order to increase attendance rates.[24]

- Satisfaction with Interventions

Patients reported high rates of satisfaction with their reminders, with 88.5% of those receiving phone calls being satisfied with reminders as opposed to 85.7% in those who received text messages. These study findings are consistent with the findings in the study by Jareethum et al in 2008 in Thailand, where pregnant women who received SMS's via their mobile phones during their antenatal period reported higher satisfaction

and lower anxiety levels than those who did not get any messages.[85] Reasons cited for dissatisfaction with reminders included language barrier and failure to receive messages. While one cannot control whether a message is transmitted or not, it should certainly be possible in future mobile phone interventions to increase patient satisfaction by using languages that patients prefer.

In terms of complications detected during the 3-day postnatal visits, twenty were reported in mothers and babies during our study period, including infections, hypertension, breast inflammation, and jaundice, leading to a complication rate of 4.8% in our study population. While the sample size in our study was too small to enable reliable estimations of postnatal complication rates in Mamelodi to be established, it was gratifying that these complications were identified in mothers and babies early because they returned for their 3-day visit.

- Cost considerations

Our cost analysis found that it was significantly cheaper to send text messages to patients than to call them, with phone calls costing almost three times more than text messages. Had we utilized a bulk text-messaging system for the study, text messages would be four times cheaper to send, leading to a difference in cost between SMS and phone calls exceeding ten-fold. Phone calls in our study were also slightly more time-consuming than text messages. For large-scale systems, it is possible to send bulk text messages (up to a thousand at a go) by computerizing the process. It is more challenging to use computerized phone calls to deliver automated messages to patients in bulk. Other studies found SMS'es to be more effective than phone calls include the

study by Koshy et al in the UK, in which SMS reminders were found to be more cost-effective than any other message used to remind patients to attend clinic.[28]

- Challenges in reaching patients

An important observation about the RCT was that it was surprisingly difficult to reach patients during follow up, with only 44% of patients picking their calls during the initial attempt to reach them. Other researchers have reported problems following up with patients on a long-term basis, because the patients frequently change their numbers and do not always inform healthcare staff about this.[18] One way to circumvent this problem is to collect as much contact information from patients as possible (e.g. collecting relatives' information), so that these alternate numbers can be used when respondents cannot be reached on their primary numbers. Given how easy it is to switch phone numbers in South Africa and given new promotions by different mobile phone companies that entice people to switch numbers and phone services; reaching people on a consistent basis will be a challenge to any mobile phone intervention.

- Site variation and need for standardized care

There was a statistically significant difference in attendance rates of patients in our study based on sites of delivery. 62.6% of mothers who delivered at Mamelodi attended their appointments as opposed to 73.9% of mothers who delivered at Stanza Bopape. This result was discussed with staff after the conclusion of the study, and a number of reasons were proposed for the differences in attendance rates. First, the patient-provider ratio in Stanza Bopape is lower than that of Mamelodi hospital, and therefore it is likely that patients at Stanza Bopape were able to get more in-depth

counseling and thus realized the importance of the 3-day visit. At Mamelodi hospital, patient counseling sessions were often communal and not personalized, making them less relevant to some individuals. It was also suggested that the staff at Stanza Bopape really emphasized the importance of the visit; as opposed to Mamelodi staff who did not consistently encourage patients to attend their postnatal visit. In addition, the facilities may have also played a role. Most patients who delivered their babies at Stanza Bopape also attended their antenatal/postnatal clinics at the same facility which is considerably newer and less crowded than other clinics. It is likely that patients had more incentive to go to Stanza Bopape for their follow up visits due to shorter wait times and better facilities there. Like our study, the study by da Costa et al also found that variations in sites affected attendance rates regardless of whether a mobile phone intervention was used or not.[14] These findings confirm that when attempts are being made to improve clinical outcomes, new interventions should not be carried out in isolation.

In addition to differences in care in sites of delivery, postnatal clinics in the study also differed in terms of the quality of care they provided. For example, in some sites, only babies were examined during the 3-day visit, while in other sites, both mothers and babies were examined. Some healthcare staff in postnatal clinics that did not routinely conduct 3-day visits admitted that they were unaware of how to completely examine mothers and babies during the 3-day visit. The inconsistency in care provision underscores the importance of continuous staff training to ensure they are aware of guidelines of care. In order for postnatal care to be improved significantly in South Africa, a multi-pronged approach that includes incorporation of mHealth as well as other systemic changes such as better staff training is required.

LIMITATIONS of the STUDY

- Sub-project A – Patterns and Preferences:

Despite carrying out the study in three provinces in South Africa, the sample size in one of the provinces (Limpopo) was too small for the data from the province to be analyzed independently. Data from Limpopo and Mpumalanga were therefore pooled to form the "rural" group, and therefore, the study results did not reflect the diversity of views from different regions of South Africa. Additionally, all the questionnaires in the study were written in English, and the language barrier might have affected a few responses.

- Sub-project B – Staff Questionnaires:

The questions that healthcare workers were asked, such as their willingness to use mobile phone technology in healthcare provision, were all hypothetical. They do not necessarily reflect staff attitudes in the real world.

- Sub-project C – RCT:

The RCT sample size was not large enough to detect any statistically significant differences between SMS and phone call reminders on attendance rates, if they were present. Additionally, the sample size was also too small to measure the effect of the reminders in preventing adverse outcomes such as post-partum hemorrhage, sepsis, and other complications. Larger sample sizes are needed to determine the effect of increased postnatal clinic attendance on postpartum morbidity and mortality.

CONCLUSIONS

The main conclusions from the study are as follows:

- Mobile phones are almost universally available in South Africa

  -They are frequently used for a wide range of functions in the country

- The use of mobile phone technology in healthcare is acceptable to patients

- mHealth is also viewed positively by staff

- A mobile phone intervention using SMS and phone call reminders is efficacious in increasing rates of follow up in postnatal clinics.

  -SMS reminders may be slightly more effective than voice reminders

- SMS reminders are less costly than phone call reminders

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