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MHealth4CBS IN SOUTH AFRICA

A REVIEW OF THE ROLE OF MOBILE PHONE TECHNOLOGY FOR MONITORING AND EVALUATION OF COMMUNITY BASED HEALTH SERVICES

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Table of Contents

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List of tables and figures

Executive Summary

Against a background of growing access to, and increasing enthusiasm for the use of mobile phone technology in health services (mHealth) in low and middle income countries (LMICs), we reviewed the potential usefulness of mHealth for monitoring and evaluation (M&E) of the planned integration of community based health services (mHealth4CBS) in South Africa. It forms part of a portfolio of support for the development of M&E systems for community based PHC outreach teams currently being implemented as part of the PHC re-engineering process. The purpose of the investigation was both to shed light on an emerging field and to provide recommendations for policy makers. We specifically sought to understand what the field of mHealth had to offer, to explore how mHealth is implemented in practice and to use these two sources of information to reflect on the lessons and implications for implementing mHealth at scale for M&E of community based services.

The review methods included interviews with key informants, three local case studies of mHealth4CBS and a review of the literature on the use of mHealth in LMICs. This report is the product of this review.

We start by providing some definitional clarity, situating mHealth in relation to eHealth and other related concepts. We then highlight the benefits of mHealth as found in the local case studies and literature. Despite promising reports and growing global promotion of information and communication technologies (ICTs), there is as yet insufficient evidence of their ability to improve the performance of health systems, especially at scale. Drawing largely on the literature, the report draws attention to gaps in evidence on the effectiveness of mHealth, as well as a number of challenges involved in the implementation of mHealth strategies. These challenges relate in part to questions of cost and sustainable financing, and in part to the challenges in creating an appropriate "fit" between mHealth technologies and other ICT systems in the health sector (the concept of "interoperability"), as well as with the needs and practices of end users. These challenges raise the need for a systems perspective that does not separate the technology from its implementation environment when appraising the value of mHealth.

We thus propose a health systems framework to guide decision-making by policy makers and managers on mHealth implementation in South Africa. The framework focuses on four dimensions: stewardship, organisational systems, technological systems and financial systems. Detailed recommendations flow from applying the proposed health systems framework to South Africa and these are outlined in the report. They include the need for strategic leadership via an eHealth strategy, the importance of aligning mHealth with organisational objectives and front end user needs, paying attention to issues of interoperability and the security of information, and prioritizing affordability and the sustainability of funding when examining technological options.

Given the findings of the review, our view is that South Africa should not opt for immediate implementation at scale of mHealth for the monitoring and evaluation of newly integrated CBS. Rather, the health sector needs to adopt a developmental approach to the implementation of mHealth by encouraging the implementation of smaller, phased and heavily evaluated 'lead 'or 'lighthouse' projects within the mainstream, routine health service environment. The focus should be on creating a learning environment that can grow a country level repository of implementation strategies and evidence of the impact of mHealth.

MHealth4CBS in South Africa: A review of the role of mobile phone technology for monitoring and evaluation of community based health services

Background and rationale

Information and communication technology and mHealth

There is growing interest and enthusiasm for modern ICTs in both high -and low-income countries, as tools that can contribute to rapid improvements in the way services are delivered to citizens. ICT in the form of electronic, internet based and mobile communication technologies are increasingly being used as communication and information management tools in the development and health sectors, with an increasing focus on their relevance to LMICs (Batchelor et al. 2003; Bukachi & Pakenham-Walsh 2007:1628; Lucas 2008; The Rockefeller Foundation 2010; Vital Wave Consulting May 2009). The World Health Organization has passed resolutions promoting EHealth as a positive tool for development and health system strengthening (WHO 2005). The growing interest is also evident in rising attendance at the annual international mHealth Summit held in Washington DC (USA) between 2009 and 2011, where the focus has shifted over the years, from trying to understand the field, to looking for opportunities to research and implement eHealth.

In the health sector, the use of ICT (often referred to as eHealth) has shown promise as tools for supporting health system functions such as data collection for surveillance and M&E, as job aids for improving clinical services to diagnose, treat and follow-up on patient care, and as tools for health promotion interventions and for health worker education (Hilbert & Lopez 2011). Modern ICT is also increasingly being promoted for use in community-based/household settings: both as research/survey tools and for monitoring and evaluation of service delivery. The forms of ICT being experimented with include hand-held electronic devices such as personal digital assistants (PDAs), electronic pens, handheld scanners and mobile phones as well as the interaction of these devices with web-based information systems. In CBS, mobile phone technology (referred to as mHealth) has become the preferred technology and the main one being recommended and studied. mHealth interventions have shown a range of benefits as tools for rapidly gathering, storing and managing health information, and to increase health worker access to information and support (Labelle 2005; Lucas 2008; Mechael et al. 2010; Mechael & Dodowa Health Research Center 2009; The Rockefeller Foundation 2010). The large–scale use of information technology for M&E of health services is still in its infancy and so is the evaluation of its impact. More information is needed on the scope of ICT, its capability, feasibility and its sustainability in a South African setting.

Monitoring and evaluation of CBS in South Africa

South Africa has a large number (+70 000) of lay health workers in the health sector, now generically referred to as community health workers (CHWs). Although the funding for their work is largely from government health departments, they are still mostly employed by intermediary nongovernmental organisations (NGOs) who provide the M&E and supervision functions and who report to government. CHWs currently perform a variety of roles from health promotion and prevention services, to treatment adherence support for TB, HIV and other chronic diseases, and palliative and 'de-hospitalised' home-based care (National Department of Health 2011).

Community based health services are currently undergoing a process of formalising and strengthening as part of a broader strategy of Primary Health Care (PHC) revitalization in South Africa (National Department of Health 2011). In the 'PHC–re-engineering' strategy, community based 'outreach' functions are being prioritised for greater investment and systems development. Outreach functions will include intensified household assessment and support, better referral to and integration with primary health care facilities and community mobilisation around priority health needs. Each health ward will have a number of PHC outreach teams, linked to local health facilities, and staffed by a combination of community health workers and professional staff.

The integration of CBS will bring greater standardisation of M&E and systems of supervision of CHWs. The National Health Information Systems Committee of South Africa (NHISSA) is currently finalizing a framework, indicators and tools for the M&E of outreach teams. This will include the integration of data elements into the District Health Information System (DHIS) and prototype tools for local supervision. Effective management of integrated CBS services at such a large national scale requires strong monitoring and evaluation (M&E) and supervision systems, hence the interest in exploring the value of ICT as a tool for M&E.

The success of community services has been linked to good quality supervision and management (Rowe et al. 2005). Whilst monitoring and evaluation of community health care work is considered crucial, it also remains a weak link in many CHW programmes, including those in South Africa. CHW programmes tend to be on the periphery of the health services and this, together with poor governance and accountability mechanisms, may be contributing to the inadequacies of M&E (Lehmann & Sanders 2007). A recent survey of community based home care services found that most of the community organisations surveyed were struggling with basic challenges such as lacking formal office and computer equipment, as well as lack of access to water and electricity – factors that could also impact negatively on any supervision system (Ogunmefun et al. 2011). Against a background of weak supervisory practices for CHWs, the need to develop adequate monitoring and evaluation systems becomes more important – as does the need to examine the potential contribution of modern information technology to enhancing M&E systems.

mHealth in South Africa

South Africa is one of the countries with the highest proportion of mobile phone users per population, with 93 out of 100 people being subscribed to a mobile phone network (deTolly et al. 2011a; Mars & Seebregts 2008). Most mobile phone users make use of short message services (SMS) as an affordable means of communicating, especially for

those who cannot afford the high cost of cell-phone calls. Mobile phones in South Africa also provide the opportunity for its users to access web-based services and information. Although the level of access to a computer and internet services in South Africa is low, a high proportion of cell phone users access the internet via their cell-phones. Thus the wide-scale availability of mobile phones and the potential for affordable communication and access to web-based services make this a potentially powerful tool for broader use in monitoring and evaluation of community-based health care settings.

Several studies have described the feasibility and benefits of mHealth technology in South Africa, including the use of PDAs and mobile phones for research, for managing community based social and health services and for health promotion and adherence support (deTolly et al. 2011a; deTolly et al. 2011b; Ogunmefun et al. 2010; Seebregts et al. 2009; Skinner et al. 2007; Tomlinson et al. 2009; Wouters et al. 2009). A South African study on the use of mobile phones for data collection for a household survey found that there were several benefits associated with being able to monitor real-time entry of data, such as performing quality checks, immediate and reliable entry and uploading to a web-based data-base via wireless technology (Tomlinson et al. 2009). Other benefits included ensuring the security of the data via unique identifiers and access control. Although not the focus of their study, the authors commented on the supervision benefits that arose from the combination of the cell-phone and web-based interface, such as monitoring of staff and programme activity. A study that compared the feasibility of implementing a surveillance system using paper-based and mobile phone methods with M&E of CHWs concluded that mobile phone surveillance was feasible and appropriate - given the benefit of immediate access to data to monitor the activities of CHWs. The authors recommended that a financial analysis be done to establish the cost of implementing such a mobile phone surveillance system at scale in South Africa (Clarke et al. 2007). These project experiences point to the potential benefits of up-scaling similar mobile phone technology for the M&E of community based health care services.

Given its relevance and the growing interest in the potential role of ICT for community based services (ICT4CBS), we conducted a review of the evidence on the use of mHealth in low and middle-income countries (LMIC), and in South Africa in particular.

Aim and objectives

The aim of the review was to provide evidence to aid decision-making by national and provincial governments on the use of mobile technologies for the monitoring and evaluation of public sector community based health services (referred to hereafter as mHealth4CBS).

The objectives were to:

1. To gain an understanding of the terrain of mHealth and it's potential for strengthening community based health service delivery.
2. To gain knowledge of the experience of and evidence on mHealth4CBS in South Africa and other LMICs.
3. To identify the key questions to be addressed regarding up-scalability of mHealth4CBS in South Africa and to make recommendations on the next steps.

Review methods

The research method was part empirical (qualitative interviews and a case study approach), part literature review and part conceptual (presenting a conceptual framework). Interviews were conducted with nineteen key informants from organisations involved in mHealth programmes in South Africa. Organizations that participated included non-governmental (NGOs) and research organisations as well as mobile phone technology service providers. For a full list of participant organisations, see Table 1. The initial list of organisations was expanded through snow ball sampling until a point of saturation was achieved. Key informants were purposefully selected based on having knowledge of their organisation's use of mobile technology.

The three cases of local experiences with mHealth4CBs were purposefully selected after completing the key informant interviews. The case studies show how three different software applications for monitoring and evaluation of community based care are used in a research and service delivery context. The study also scoped new government/ NGOs partnerships such as the NDOH project (currently being operationalised) for deploying over 10 000 cell phones for rapid monitoring of the HIV Counselling and Testing (HCT) campaign, in partnership with the Health Information Systems Programme (HISP) and Cell-life.

Key informant interviews explored the organization's experience of implementing ICT for research and M&E of community based care services, reflecting on the benefits and challenges and lessons learnt that may be relevant to up-scaling ICT use for CBS in South Africa. Key informants included programme managers, principal researchers, and supervisors in CBS and in companies that provide mobile phone software applications. Key informant and case study interviews were conducted by the first author and face to face with individuals or pairs. In one case the interview took the form of a group discussion with four managers from one organisation who themselves were exploring their options for using ICT for monitoring and development of their home–based care services. The interviewer made extensive notes during the interviews. The interviews were recorded on a digital recorder and used as a source of back-up information.

The indexed and grey literature on the use of mHealth in community based health services was reviewed to understand the context, scope, purpose and effectiveness of the ICT used in various projects. Information was also drawn from attendance at a local mHealth conference hosted by the Medical Research Council of South Africa (MRC) in Cape Town in September 2011 and from reviewing conference proceedings of the international mHealth Summit held in Washington DC in December 2011. The findings were presented to the National Health Information Systems Committee of South Africa (NHISSA), in November 2011 and the draft report was circulated for comment to the research participants. This final report includes the comments received from the NDOH and the research participants.

Data from the interviews and literature review were analysed using a thematic content analysis approach in order to identify the main trends/themes in relation to the questions of interest. The main challenges that the literature and case studies identified related to health systems issues. These health systems challenges were grouped into four categories and re-conceptualised as a health systems framework. We used the framework to reflect on how the evidence and lessons learnt may be applied to South Africa, which may have broader relevance for mHealth decision-making in other LMICs.

Ethical approval for the study was granted by the Ethics Committee of the University of Western Cape. Key informants were required to give written informed consent.

Table 1: Key informant interview participants

Organisation	Type
Health Systems Research Unit, Medical Research Council (4 key informants)	Research organisation using ICT for data collection in various research projects on community based health interventions
Community Media Trust (1 key informant)	A NGO specializing in producing audio-visual and other health promotion material. The provide health promotion at clinic and community based settings using community based health promotion workers.
Philani Nutritional Project (1 key informant)	An NGO in Khayelitsa specializing in promoting the health and well-being of mothers and babies in impoverished areas. They use a model of support where mothers are mentored by "Mentor Mothers" in a community based setting.
Health Systems Trust (2 key informants)	Organisation that evaluated the use of mobile home technology, using software applications from Geomed, in two community-based health care organisations.
Hospice Care Association of South Africa (4 key informants)	Country –wide NGO providing home-based palliative care services. The organisation is currently investigating various ICT options for improving their monitoring and evaluation.
The SEED Trust (1 key informant)	An NGO providing management support services for the development of community-based interventions.
Telemedicine Unit, Medical Research Council (1 key informant)	Unit of the MRC specializing in designing Telemedicine stations and evaluating its effectiveness.
Health Information Systems (HISP) Programme (1 key informant)	An NGO that designed the current electronic routine monitoring system for health information. HISP and Cell-life have combined efforts in a project initiated by NDOH- for the implementation of a large mHealth project for monitoring of HCT and CBS information.
Clyral (1 key informant)	For profit provider of software application for research, NGO and commercial applications.
Cell-life (1 key informant)	Not for Profit provider of open-source software application for research, NGO and government.
Jembi (1 key informant)	Lead organisation developing eHealth architecture in African countries. Not for profit.
Mlab (1 key informant)	For profit, providing a range of ICT services for commercial and NGO services.

Findings

There are three categories of findings presented in this report. The first is a set of concepts and definitions, demystifying the various ICT terms being used, and showing how mHealth for community based health care is connected to the broader terrain of eHealth. The second set of findings report on the local case studies which show the benefits and challenges of mHealth for CBS in practice in South Africa. The third set of findings reflects on the limits of current evidence. On the basis of the gaps in evidence, we propose a health systems framework for categorizing the systems challenges identified in the literature. This is followed by a section titled '**Applying a**

health systems framework to South Africa', where we apply the proposed health systems framework to South African situation. The report concludes by making specific policy and practice recommendations for South Africa, using the proposed health systems framework as a guide.

What is mHealth4CBS?

Concepts and definitions

The term 'information and communication technology' or ICT, is an umbrella term for the use of some form of technological device or system to aid communication, information access, information management and service delivery activities. This could include older technologies (such as the radio) and newer internet and mobile–phone based technologies. It thus encompasses a very wide range of health sector processes and technology, many of which have become a routine part of service delivery (such as desk top computers). The term ICT is used across disciplines, for example in computer studies, development studies, and in health and social services.

Within the ICT field there are a variety of overlapping terms and definitions that can sometimes cause confusion. For instance, one study found 36 different definitions of eHealth (Chetley 2006) before settling on an adaptation of one definition (presented in the table below). Table 2 below clarifies some of the ICT concepts and definitions used within the health and development service sectors.

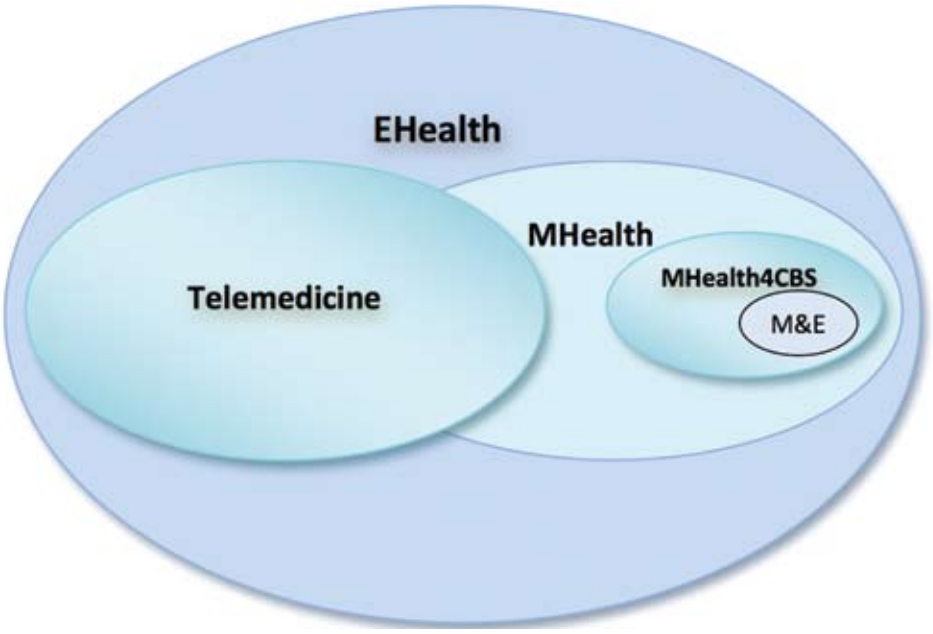
Table 2: ICT concepts and definitions in the health and development sectors

Term	Definition
eHealth	EHealth is a broad term for the full spectrum of technological applications of ICT in health. The main objective of eHealth is to use ICT tools to improve healthcare service delivery. EHealth captures all the components that may be part of an ICT system, including static or mobile devices, mechanisms for transporting signals and for management of information such as satellite receivers, the internet and computers. There is a wide range of eHealth interventions where the end–user is the health professional, such as Electronic Health Records (EHR), e-Prescribing, ordering and communicating results of diagnostic tests and radiology, decision–making job aids at the point of care and for delivering care at a distance, such as in telemedicine. One definition offered in a report by InfoDev, is their adaptation of a definition by Eysenbach (2001) which reads as follows: *'e-health is an emerging field of health informatics, referring to the organisation and delivery of health services and information using the Internet and related technologies. In a broader sense, the term characterises not only a technical development, but also a new way of working, an attitude, and a commitment for networked, global thinking, to improve health care locally, regionally, and worldwide by using information and communication technology'* (Chetley 2006:10)
mHealth	*"Mobile health information technology (or mHealth) is a sub section of eHealth in that it refers specifically to the use of mobile information technology to improve health service delivery. MHealth technology involves portable hardware devices (such as cell phones, digital pens, PDA or other handheld devices) as well as the software applications and satellite and internet and wireless networks that allow for the rapid transmission, storage and retrieval of electronic data. MHealth can also be used in conjunction with other non-mobile eHealth interventions, for instance, where a clinician can use a portable device to access electronic patient records, for e-Prescribing, ordering diagnostics or managing patient referrals."* (The Rockefeller Foundation 2010:30)

Term	Definition
ICT4D	The term refers to the use of modern ICT as a tool in development projects, for instance where the focus might be poverty alleviation through increasing access to information and skills.
ICT4CHW or ICT4CBS	ICT for community health workers (ICT4CHW) is a term used in the literature to describe the use of ICT for improving the delivery of community based health or social service programmes.
mHealth4CBS	This is the term used in this review; to describe the use of mHealth interventions to improve service delivery of community based health care services. In mHealth4CBS, the end user could be the health personnel delivering community based services as well as the patients who may be using their cell-phones to receive or access health information.
Telemedicine	In telemedicine the focus is on improving access and quality of clinical services that can be delivered over a distance, using eHealth interventions (Pisasale & Holt 2009). Telemedicine could employ both static and mobile-information technologies.

Figure 1 below provides a visual representation of how these terms relate to each other. In the health sector eHealth provides an umbrella term for various overlapping functions with mHealth as a sub-section within eHealth. Telemedicine and mHealth can also overlap as mobile technology can be used in both clinical and non-clinical applications. The figure shows that monitoring and evaluation of CBS, which is the focus of this review, is a small part of mHealth4CBS. Because of the interconnectedness of the concepts, most of the key mHealth issues and challenges discussed in this report can equally be applied to field of eHealth in general.

Figure 1: ICT, eHealth and mHealth concepts



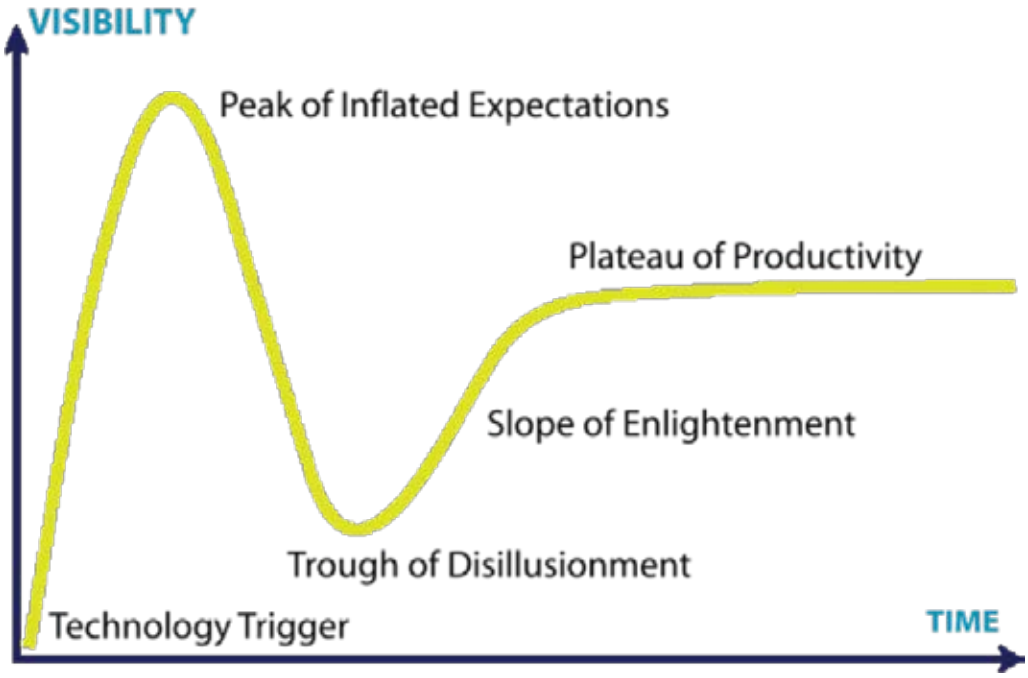
Why mobile phone technology and why now?

Mobile phone technology is expanding in scope (in terms of technical functions) and availability. The majority of mHealth interventions use mobile phone technology as compared to other mobile handheld devices such as PDAs and digital pens. The attraction of mobile phones over other mobile devices may be due to its versatility as an ICT tool - it can be used for voice communication, texting, for data collection

and transfer and for accessing information from the internet. Internet applications are also increasingly being adapted for mobile phones, further enhancing the utility of mobile phones. Another reason for the increasing focus on mobile phones is the growing accessibility of mobile phones in LMICs, and the widespread familiarity with the technology, thus presenting opportunities for introducing mobile-phone based interventions in different spheres of life, including in health services (deTolly et al. 2011a; Tomlinson et al. 2009).

Some have argued that part of the reason for the high levels of interest and enthusiasm for mobile phone technology is due to its newness and consequently, accompanied by inflated expectations. Gartner's 'Hype cycle ', seen in Figure 2 below, was proposed in the 1950's to explain the pathway followed when new technology is introduced and how it cycles through phases of expectation, maturity and adoption (see www.gartner.com/technology/research/methodologies/hype-cycle.jsp#). The 'hype cycle' is often referred to in discussions on mHealth to reflect on where we might be in the cycle of introducing new technology. During the 'Peak of inflated expectations' phase there are usually many success stories that are widely publicized, but accompanied by many failures as well. At this stage some organisations may take action to use the technology and some not. This could be followed by a period of disillusionment, when the inflated expectations deal with the reality of feasibility and applicability. On the 'Slope of enlightenment', the benefits of the technology start to crystalise more, new generation products start to emerge and pilot implementation and research are increasingly funded. During the last phase of adoption, the criteria for success and for viability become more clearly defined and there is broader market applicability. Some have argued that it is only a matter of a few years before mobile phone technology is part of routine use in mainstream health services – which would represent the 'Plateau of productivity'.

Figure 2: The Gartner 'Hype cycle': a graphic representation of the maturity and adoption of new technology



How does mobile phone technology work?

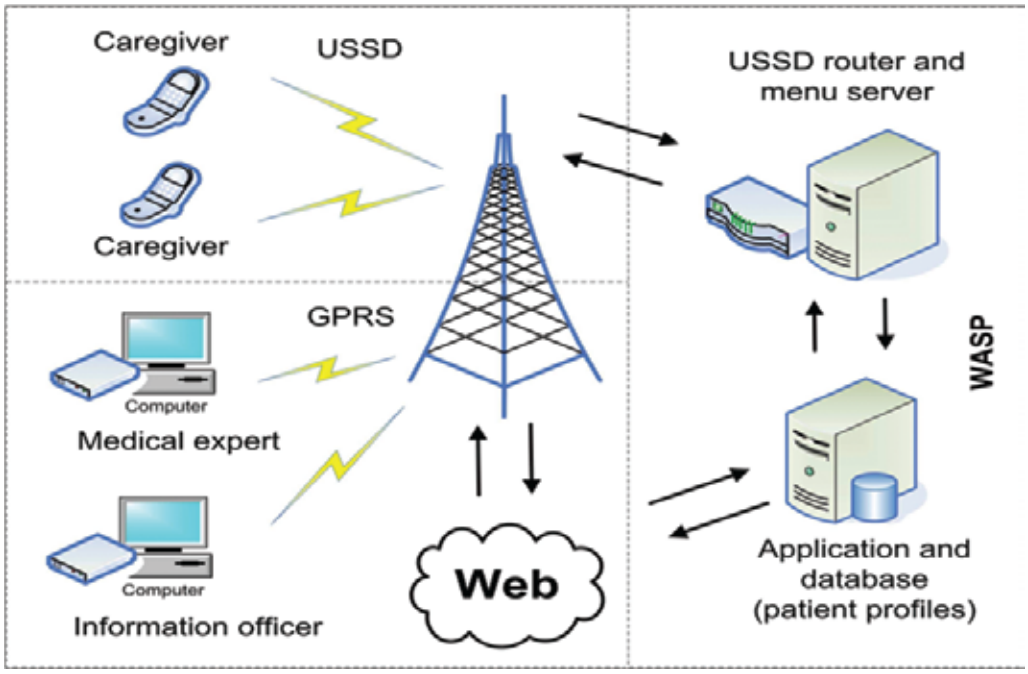
MHealth can be viewed as performing three different technological functions, namely to:

- Transmit and communicate information (movement of information through space)
- Store information (movement of information through time, enabling sharing of data on a web-based system)
- Compute information (transformation of information) e.g. aggregation of data, validation & manipulation/calculation/analysis of data to generate reports (Hilbert & Lopez 2011).

Mobile phone technology usually includes equipment such as handsets, computers, servers, and software and bandwidth connectivity - components involved in the data collection, transfer, storage, transformation and management of information. It includes the main function of voice communication and supplementary functions such as SMS, imaging and video. Mobile phone technology uses different systems or "protocols" for communicating signals. The different protocols may have different capabilities (and costs) in terms of the type and amount of data they transmit, and some may depend on having more advanced devices, such as smart phones. The protocols include Global Positioning System (GPS), General Packet Radio Service (GPRS), Unstructured Supplementary Service Data (USSD), Bluetooth, web browsing and cell broadcasting. There are a variety of health-related software applications that use different combinations of these functions and communication systems (Mechael et al. 2010).

As illustrated in Figure 3 below, there are several components that make up the telecommunication architecture of a mobile phone system and different pathways of information flow. The mobile phone handsets transmit signals via a satellite receiver to a web-based server or router. Communication and interaction can then occur between the web-based data and specially designed software applications on various computer terminals (via wireless technology or WASP). The software applications manage the data and can transform it into meaningful information, such as aggregated data on various activities, workers or patients. The information sent from the mobile phone would then be received by the information officer, supervisor or medical expert, via a computer terminal (such a computer terminal is sometimes referred to as a management console). The mHealth system would allow for feedback via the same telecommunications system between the frontline user and the users of the management or supervisory console. For instance, with CBS, the community health worker could be notified that their information was received, or given feedback on their performance or they could receive follow-up information on a sick patient they may have referred.

Figure 3: A broad overview of mHealth infrastructure, protocols and flow of information



Source: (Wouters et al. 2009).

The various applications of mHealth

Mobile phone technology has been applied for various purposes in health. These include using it as a data collection tool for research and disease surveillance, for management in administration, planning, monitoring and evaluation of services. It can also be used to support clinical service delivery through point of care decision making aids and as a tool for diagnostic and referral mechanisms. It is often used as a tool for health promotion and disease prevention, for example in patient health awareness and adherence support. Finally, mHealth is also employed as an educational tool for health workers, for instance, providing distance learning opportunities. These multiple uses of mHealth show the wide scope and potential of mHealth interventions. It does however also make it more challenging to evaluate, as the different applications have different objectives and outcomes.

Another way to view the various uses of mHealth is through the lens of its ultimate purpose. In his review of future health systems in LMICs, Lucas (2008) suggested that there are two distinctive purposes for ICT (Lucas 2008). The first is as a tool for supporting existing practice, such as improving the management of day-to-day functions of the health system. The second purpose is to transform and 'revolutionize' the way the health system functions. With the latter, the use of ICT changes not only the ways information and clinical services are accessed, but may also shift the power dynamics within the health system between users and providers (Lucas 2008). An example of transformative mHealth is where patients would be able to access their medical records via their mobile phone or seek a second medical opinion via a tele-doctor service.

Table 3 summarises the various applications of mHealth as reported in the literature. mHealth applications are categorised according to the function and objective of the intervention as well as whether the particular example could be considered supportive or transformative in its aim, bearing in mind that the distinction may not always be clear cut and that both might be operating.

Table 3: Functions of mHealth: supporting and transforming health care delivery

Function mHealth	Supporting existing functions	Transforming existing functions
Data collection	For research and disease surveillance	Disease and epidemic outbreak tracking, including systems for rapid communication of disease outbreaks.
Management	Management of health information for planning, monitoring, evaluation and supervision of workers and service delivery. Support for managing information and scheduling of home visits of community-based services. For administrative help with data collection and rapid reporting. Facilitating communication amongst CHWs and between CHWs and supervisors. Improving the functioning of administrative systems for human resource management, financial management, supply chain management and other support services.	Systems that automate key supervision processes, provide alerts for high risk situations and patients, and feedback loops to workers. Bi-directional automated referrals and feedback between community and clinic services. Automated payment systems using cell-phones On-line personnel leave applications.
Clinical service delivery	Providing support for health workers at point of care for diagnosis and treatment. This could be via electronic guidelines or referral mechanisms Providing job aids & decision-making tools for service delivery.	Call centre triage and support for patients prior to accessing clinic based services. Telemedicine also make use of mHealth applications. It expands clinical care to support health care workers remotely-including providing complex surgery via ICT. Algorithms for CHWs to screen and diagnose, refer and access medical expertise in the field. Automating pharmaceutical dispensing Emergency health response systems that are linked into existing or specialized EMS services.
Health promotion	Support for managing information and scheduling of home visits and health promotion activities. This can include public education and awareness interventions.	Promoting adherence support and increasing access to screening tests through SMS reminders. Audiovisual applications available on mobile phones to use as a job aid for CHWs.
Health worker education	Training personnel via distance learning opportunities. Evaluate the impact of the education through distance quizzes. Ongoing training through regular electronic updates and access to reference material.	Opportunities for virtual accompaniment of health worker for supervision and/or in service training.

The examples given in Table 3 are drawn from various sources including the following: (Alam et al. 2010; Batchelor et al. 2003; Bukachi & Pakenham-Walsh 2007; Chen Jan 2008; DeRenzi et al. 2011a; DeRenzi et al. 2011b; deTolly et al. 2011a; deTolly et al. 2011b; Florez-Arango et al. 2011; Free et al.; Ivatury et al. 2009; James et al. 2011; Labelle 2005; Lester et al. 2009; Lobach et al. 2001; Lucas 2008; Pisasale & Holt 2009; Rowe et al. 2009; The Rockefeller Foundation 2010; Treatman & Lesh 2011)

Case studies of mHealth in South Africa

Based on interviews and literature, three case studies of mHealth in CBS were selected for review to gain a more detailed understanding of how mobile phone technology is used in practice. Each case study describes the context in which mHealth is used, the rationale, the aim and the nature of the software applications. The case studies also report on the organizations' perception of the benefits and challenges of using mHealth.

The three case studies show how different types of software applications for mobile phones are used for similar functions to assist with monitoring and evaluation activities of community-based work.

Case Study One: MRC Health Systems Research Unit

CONTEXT

The Health Systems Research Unit (HSRU) of the Medical Research Council of South Africa (MRC) has been using mobile phone technology to assist with data collection for community based surveys and with the monitoring and evaluation of their cadre of field workers, known as community health workers. Mobile phones have been used in several of their community based controlled trial on the effectiveness of various community-based health care interventions to prevent Mother to Child Transmission (PMTCT) of HIV, known as the 'Good Start' studies. One study tested interventions to save lives of newborns via pre and postnatal community care and another assessed uptake of home-based HIV testing.

THE PROBLEM

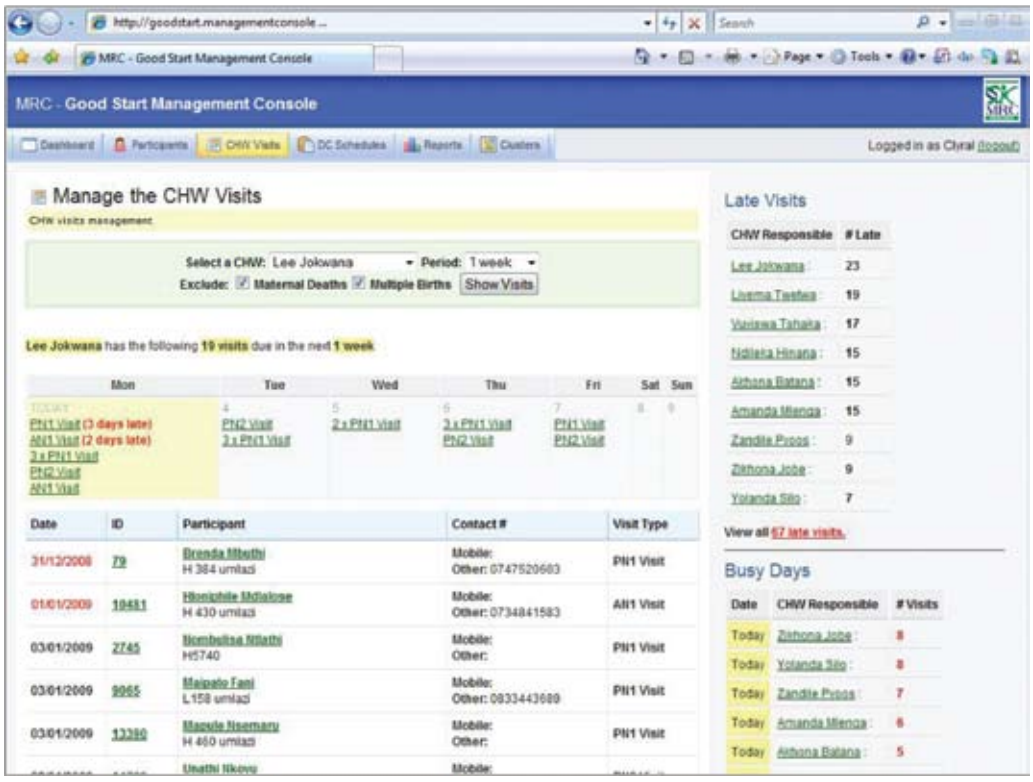
The research involved home visits by trained lay community health workers to promote appropriate and exclusive infant feeding practices in the one study and home-based HIV testing in another. The infant feeding study required data collection for baseline and follow-up surveys at intervals of several months for over 2 000 mother and child pairs. The researchers needed quick access to survey data and systems for managing a group of over 30 CHWs. Past experience with using paper-based systems for collecting this survey data presented several challenges in terms of the logistics and costs of printing, transporting, and storing paper forms. Data entry required separate personnel and caused delays in access to the data. Supervision of CHWs was challenging as they were spread over a wide geographical area and could not easily meet regularly.

THE SOLUTION

The project used mobile phones technology for data collection, transfer, storage and management of data. Using the **Mobenzi Researcher** (developed by Clyral) software application, the researchers designed custom-made electronic forms for collecting data. It also had a custom-designed management console, called the Good Start Management Consol (GSMC) - to monitor the completion of surveys and to manage the CHW's activity via a purpose–built website. CHWs collected survey data on electronic forms that were pre-loaded on their cell-phones and were able to immediately enter the data and transmit this via their cell-phones, using internet connectivity, to a computer server that managed the data collection process. Operational information from each home visit by a CHW was also recorded and this was used to plan and monitor the visit schedules of CHWs.

The GSMC can manage information from mobile phones and other sources, to analyse the data recorded, manage the tracking and scheduling of home and antenatal visits and co-ordinate and monitor project activities. It is able to auto-generate aggregated reports on data collected (when, who, how many, where) and to check this against planned schedules. For an example of what an element of the GSMC looks like, see Figure 4 below. The figure is a snapshot of a computer screen that illustrates a set of aggregated data based on the work profile of one CHW. On the screen, it shows how the GSMC tool can identify the number of home visits completed, compared against the planned schedule, the type of visits due, which were missed or late. It also indicates the average number of home visits per CHW for the one week period as well as the number of late visits per CHW.

Figure 4: Illustration of Good Start Management Console (GSMC) tool



Source: Clyral website

Benefits

- Removal of pen and paper-based forms meant an increase in convenience and efficiency of data collection, data transfer and data storage.
- Cutting out paper was reported as saving costs of paper, transport and storage.
- Rapid access to data allowed for real-time monitoring and rapid analysis and sharing of data.
- Updating of electronic data entry tools (surveys) and access to latest version was more efficient.
- The programme did not require separate data entry personnel.
- Data entry accuracy was promoted through using 'skip logic 'in electronic forms.
- Management console provided various tools and information that can be used to improve supervision and management of the intervention.
- Effectiveness of weekly supervision meetings was enhanced due to the wealth of information available, including ability to generate up to date individualized work schedules for CHWs.
- The use of proprietary software meant that technical support for data management and maintenance of technical systems was readily available.

Challenges

- Initial technological challenges with software needed to be addressed.
- Management needed a clear policy on care and loss of mobile phones to prevent misuse by frontline users.
- Not all CHWs were equally comfortable and capable of managing mobile phone technology.
- Not all patients were equally comfortable with use of cell-phones by CHWs.
- Supervisors and managers needed to be trained to use the management console appropriately.
- There were high start-up costs associated with design of software, transmission, and management of server for storage when using non-open source software. This was partially off-set by using the same software in multiple projects.
- The use of proprietary software meant that issues of ownership of the software application needed to be addressed.

Case Study Two: Community Media Trust [1]

CONTEXT

Community Media Trust (CMT) is a country-wide social media NGO (with its head office in Cape Town) that provides community based health promotion interventions. They use mobile phones as a monitoring and evaluation tool where CHWs (referred to as 'Treatment Literacy Practitioners') report on their work activities. The efficacy and costs of this system were evaluated in an initial pilot study where the new electronic system, called EMIT (later changed to 'Capture') was compared with the paper-based process. The study included measures of cost (handsets, airtime usage), turn-around time from the time of an event to when reporting was available electronically, and accuracy of reporting. The full

1. The case study information was extracted from the Cell-life website and was confirmed via a key informant interview.

costs of the intervention could not be calculated as the software was partly subsidized by the software developer (www.cell-life.org).

THE PROBLEM

The amount of paper work having to be collected, transported and then captured was becoming problematic for CMT. Approximately 1400 forms where being sent to the head office weekly which resulted in a considerable lag between the day the data was collected, and the day a manager could analyse the data electronically.

"We had people capturing data online in their remote offices from their paper based forms collected during the week. The issue was that uploading data using 1 or 2 office computers took a long time on a Friday when staff meet weekly for training and support purposes – the time taken to upload data was impacting negatively on the purpose of the meeting. If all data was not uploaded on one Friday, it was left for the following week resulting in backlogs. This resulted in issues for generating reports from head office in time for our funders and not including all the data for the reporting period because it was late – leading to under-reporting on the number of people reached in a given period. Also, delays meant it was difficult to give timely feedback to the facilitators and make management decisions based on the data." (Ms. Debbie Kroon of CMT quoted in case study on www.cell-life.org)

THE SOLUTION

A mobile data collection system entitled **"Capture"** was developed to enable Treatment Literacy Practitioners (TLP) of CMT to report core indicators of their daily work. **Capture** allowed fieldworkers to fill in forms on their cell phones from any location. Because Capture is mobile and web-based, data is captured and can be analysed immediately, offering faster feedback and greater accuracy, while saving the costs of manual data capture. This process, from data collection to analysis and reporting, is illustrated in Figure 5 below.

Each TLP visits several clinics or schools per day, providing education on a range of HIV topics. The key indicators of each session (e.g. number of attendees, type of message delivered, date and location) need to be collected effectively and accurately so CMT can monitor its intervention efforts. After a successful trial with fieldworkers capturing their forms weekly using a web interface, CMT then piloted with a group of users submitting forms *daily* using their mobile phones.

Benefits

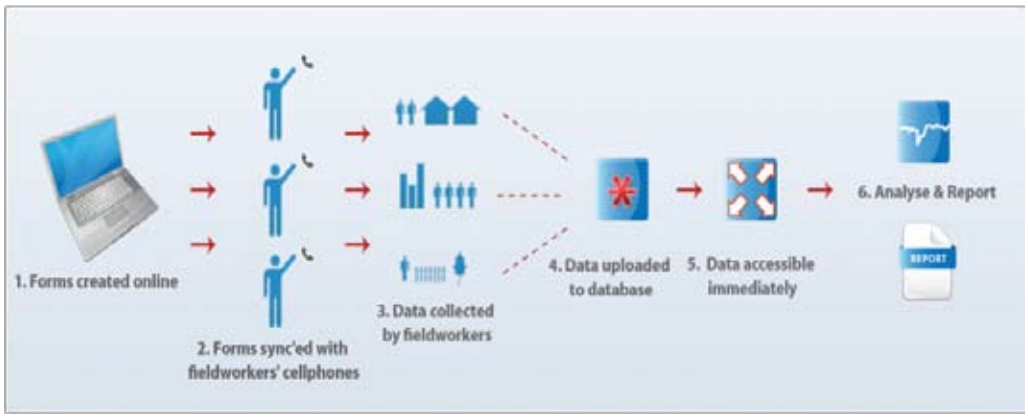
- Using mobile phones to submit data daily improved the efficiency and accuracy of submitting data. This, in turn, allowed for quicker analysis and reporting.
- There was less paperwork and administration for the TLPs and it gave management quicker access to cleaner aggregated data. The results from the impact study showed reduced turnaround time between a work session being performed in the field and a manager having access to the report electronically:
  - using a paper system: around a month
  - using a web based system: around 5 days (due to access to PCs)
  - using a mobile phone: around 1-2 hours

- There was increased accuracy of data submitted as the electronic system does not allow incomplete surveys to be submitted.
- There was a decrease in data entry error (errors resulting from manual transcription from paper-based forms to computer data entry).
- EMIT/Capture software is built using 100% open source tools which reduced the costs.

Challenges

- The organisation needed a clear policy on care and loss of mobile phones and this required strict enforcement to prevent staff negligence.
- There were limitations in terms of transformation of data for reporting as the software application was not fully developed to generate management reports automatically.
- There were some limits to the complexity of type of questions that could be included in the electronic questionnaire.
- Full economic cost evaluation was not done as the project was given financial concessions for piloting the software.

Figure 5: Illustration of Capture data collection system



(Source: www.cell-life.org)

Case study three: Nompilo system for M&E of community based organisations[2]

THE CONTEXT

In 2001, the Health Systems Trust (HST), a public health NGO, completed an evaluation of the utilization and efficiency of mobile phone technology, using the Nompilo software application, for M&E of CHWs in two NGOs. The NGOs using Nompilo software were Choice Trust in Limpopo province and the Valley Trust in KwaZulu-Natal province. The intervention involved thirty CHWs from

2. The details of this case study were extracted from the evaluation report compiled by HST and confirmed through an interview with the researchers.

each organisation compared to a control group in the same two organisations who continued with paper-based systems.

THE PROBLEM

To monitor the activities of CHWs (referred to as Community Care-Givers – CCGs), the organisations used paper-based M&E systems that required the CHWs to fill out daily activity forms. On a monthly basis they then presented this aggregated information to their local supervisors. These reports were then aggregated and reported to NGO donors and the relevant Health Department.

The M&E system of the community based organisations was reportedly beset by a host of challenges and shortcomings. These included long turnaround time for data collection, absence of standard data collection tools, manual systems for aggregating data and generating reports which were time consuming to produce and difficult to check for errors, and no direct ways to monitor staff who are spread over a wide geographical area.

THE SOLUTION

Nompilo is a mobile-phone based software application that enables CHWs to easily document patient information in a paper-free environment, in real-time. It aims to help reduce operational inefficiencies and deliver cost-savings and enable health and social care workers to enhance their work as CHWs. The CHWs use a patient specific bar code to log into the Nompilo system through her/his phone in order to update the patient's records during his/her visit. The data is captured centrally on a web based patient and workforce management system. Using a web browser at clinic level, doctors, nurses and supervisors of CHWs can interact and monitor the data and respond where necessary.

"The Nompilo system thus allows for real-time, intelligent data reporting that effectively automates the monitoring and evaluation activities that are required of a CCG [CHW]. Being able to update the patient's records during the visit, means that data accuracy is improved, and having the information stored in a central storage space allows for the bi-directional flow of information between the CCG and the clinic." (Extract from Geomed website at www.geomed.co.za)

Benefits

- The HST evaluation found that the utilisation of the electronic solution was more advantageous when compared with the paper-based system. With electronic solution CCGs were able to collect information on a patient faster (30 minutes vs. 60 minutes for paper). CCGs compiled a report for their supervisor in less than 90 minutes (versus up to 3 hours for paper).
- Some improvements to work practices included that CCGs could more easily keep their patient's records secure and confidential, they conducted more home visits in a day and they could review their own electronic data instantaneously.
- It also enabled supervisors to do closer monitoring of CHW activities.

Challenges

The HST evaluation report highlighted the following challenges:

- There is a need to build capacity of management and supervisors for using the information available on the management portal, for the purpose of strengthening health care delivery.
- Enough time should be allocated to implementation of new electronic systems, at least a year.
- The electronic solution cannot easily capture qualitative data.
- There is a need for the electronic solution to be available in indigenous languages.
- There is a need to build more capacity for local technicians that can assist with technical problems and maintenance.
- Reliable internet connectivity is important to prevent breakdowns in the monitoring and evaluation system.
- Lastly, the evaluation study made the following set of recommendations:
    - Buy-in of all stakeholders is needed in order to ensure funding and other resources for sustainability purposes
    - Adapt the programme to collect information on other CHW services such as services for orphans and vulnerable children (OVC)
    - Produce a manual in other official languages, besides English, for CHWs and the management.

Gaps in evidence and implementation barriers

The positive role of mHealth found in the above case studies has also been reported in literature from other countries (Alam et al. 2010; Armstrong et al. 2009; Avgerou & Walsham 2000; Batchelor et al. 2003; Bukachi & Pakenham-Walsh 2007; Chen Jan 2008; Chetley 2006; DeRenzi et al. 2011b; deTolly et al. 2011a; deTolly et al. 2011b; Fairhurst & Sheikh 2008; Free et al.; Rowe et al. 2009; Skinner et al. 2007). The local case studies experienced very few problems with the technology itself or with their project implementation. What these local and other case studies are not able to tell us, however, is the extent to which the identified benefits of mHealth would be retained when up-scaled to a mainstream health service. Reviewers have recognised this as a key limitation in the evidence on mHealth (Bukachi & Pakenham-Walsh 2007; Mechael et al. 2010; The Rockefeller Foundation 2010). For instance, there are only two main examples of successful large scale eHealth projects mentioned in the literature and those are the medical services of the Veteran's Association in the USA and the New Zealand health system. Most mHealth interventions considered successful in LMICs are based on small projects, often non-governmental and not integrated into mainstream government health services. Moreover, the evidence of success in these smaller organisations is often based on pilot studies and focused on feasibility, rather than effectiveness and cost effectiveness. As one review concluded:

"To scale up these benefits will require a better understanding of local conditions, better training of health workers, and appropriate choice of ICT tools." **(Bukachi & Pakenham-Walsh 2007:1628)**

Whilst the local mHealth case studies typically experience and report only minor implementation challenges, recent reviews of mHealth projects have begun to highlight a range of implementation barriers in both high and LMIC settings, offering a more macro perspective on the use of mHealth interventions that goes beyond the micro level of

analysis of individual case studies. These barriers relate to issues of leadership and support, the challenges of changing health personnel practice, technological challenges with integration of information and organisational systems and challenges of sustainable funding. The Rockefeller Foundation in their report identified six key system challenges facing most ICT for development projects, irrespective of the income levels of the country (The Rockefeller Foundation 2010). These challenges were echoed in other reviews – one conducted by the Earth Institute of Columbia University focusing on LMICs (Mechael et al. 2010) and another, a systematic overview on the effectiveness of eHealth (not only mHealth) interventions (Black et al. 2011). The six challenges, when applied to mHealth in LMICs, will be outlined in more detail in the next section of this report and are listed below:

1. The lack of alignment with and integration into health sector plans, strategies and systems.
2. The absence of government leadership and coordination.
3. Poor documentation of and learning from best practices.
4. The challenge of identifying and using affordable open-source options.
5. The challenge of ensuring workable approaches to privacy and security.
6. The challenge of finding workable approaches to inter-operability.

"In the light of the paucity of evidence in relation to improvements in patient outcomes, as well as the lack of evidence on their cost-effectiveness, it is vital that future eHealth technologies are evaluated against a comprehensive set of measures, ideally throughout all stages of the technology's life cycle. Such evaluation should be characterised by careful attention to socio-technical factors to maximise the likelihood of successful implementation and adoption."
(Black et al. 2011:abstract)

Another gap in evidence is knowledge of the requirements for successful adoption of new technologies such as mobile phone technology. A Cochrane review of the effectiveness of interventions to promote the adoption of ICT by healthcare professionals concluded that little is known about how to achieve the successful integration of ICT into practice (Gagnon et al. 2009). In their systematic review of eHealth, Black and colleagues concurred and noted that this highlighted the need for continuous evaluation of implementation:

This gap in evidence in the field of mHealth implementation may be in part due to an absence of a single framework within which to evaluate the different ways in which ICT tools help to strengthen the health system (De Renzi et al 2011a).

A health systems framework for decision-making about mHealth

Against a background of identified implementation barriers, gaps in evidence on effectiveness, and the absence of a standard evaluation framework against which to measure outcomes, it remains a challenge to appraise the true impact of mHealth, at scale, for mainstream health services. We would like to suggest that the identified barriers and gaps point to the need to consider a broader health systems perspective to guide decision-making on the implementation of mHealth in mainstream health services and propose a framework to achieve this.

There are several suggested frameworks to assess readiness of an organisation to implement innovative ICT, such as, for instance, eReadiness tools where eReadiness is considered as "*the degree to which users, healthcare institutions, and the healthcare system itself, are prepared to participate and succeed with e-health implementation*" (Khoya et al. 2007:425). Such tools can be useful on an operational level, once the decision to implement mHealth has already been made. However, there is an absence of a framework to guide policy makers and health managers in their decision about whether to embark on implementing mHealth interventions and what the health systems requirements would be for effective implementation.

Drawing on the challenges identified in the literature and information from the interviews and local case studies, we propose a health systems framework that could guide decision-making about mHealth implementation in South Africa. The structure of the framework is drawn more specifically, from two sources that look at the requirements for successful ICT implementation. The first source is a review of information technology for health in developing countries (Bukachi & Pakenham-Walsh 2007). The authors categorise the systems challenges faced by developing countries as the 'Four C's':

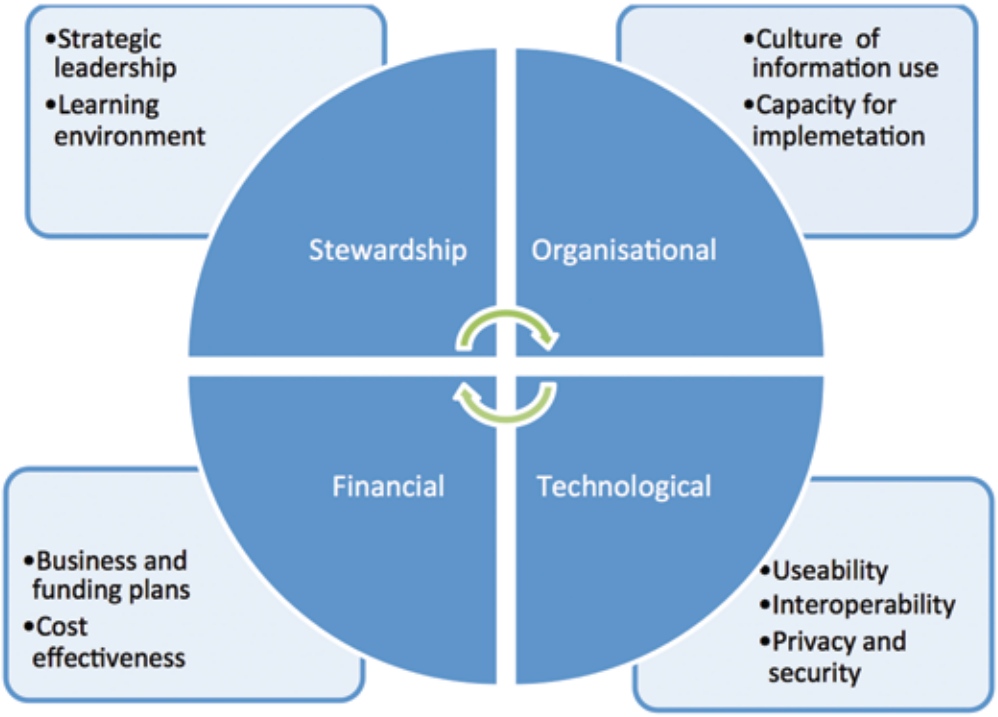
"The implementation of health ICTs in developing countries and in sub-Saharan Africa in particular has been hampered by traditional obstacles: poor infrastructure; lack of resources; and insufficient political commitment and support. This can be aptly summarized as the "Four Cs": connectivity; cost; capacity; and culture."
(Bukachi & Pakenham-Walsh 2007:1624)

The central message of their review of ICT was that "infrastructural and cultural contexts vary and require different models and approaches" and that contexts usually vary in the four areas they identified. The 'Four Cs' are 'Culture' of information and technology use, 'Capacity' to manage the effective implementation, use, and maintenance of the new information technology, 'Connectivity' which refers to the interlinking or interoperability of information and technology systems and finally, the financial 'Costs' of implementation.

The second source we draw on for the framework is an analysis of the prerequisites for sustainable ICT development in LMICs (Ali & Bailur 2007). The authors defined 'sustainability' as: *"to continue and maintain in a certain state'*, to *'keep or maintain at a proper level or standard'*; and *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs*"- definitions that would all be appropriate when applied to projects using mobile phone technology. They identified five components to sustainability namely: institutional/organisational, social/cultural, financial, technological, and environmental sustainability. The authors posed key questions that need to be answered in each area and these will be used as guiding questions for the various dimensions of the health systems framework presented below.

Drawing largely on the systems barriers that have been described in the literature and the categories proposed by the two sources described above, we re-conceptualised the barriers and prerequisites for success as four key, interlinking health systems dimensions that should be considered when making decisions about mHealth implementation in South Africa. As shown in Figure 6, they are: government stewardship, organisational systems, technological systems and financial systems. For each of these four dimensions, we pose a key health systems question to guide the decision whether to implement mHealth and what would be required to implement it successfully, with reference to the South African setting.

Figure 6: Health systems framework for decision-making on mHealth



Applying a health systems framework to mHealth decision-making in South Africa

1. Stewardship: Is there a policy environment supportive of mHealth4CBS?

LESSONS LEARNT

A key barrier to the sustainable implementation of mHealth projects in mainstream health services seems to be the absence of government leadership and co-ordination. For instance, the Grameen Foundation observed that in Ghana there was little co-ordination between mHealth projects within government and between government and NGOs projects. Government stewardship is important for creating an environment conducive to the innovation, development and effective implementation of mHealth. As suggested in the Grameen Foundation report on mHealth in Ghana:

> *.."this will no doubt take a comprehensive, coordinated effort between the government, NGOs and telecommunications providers to have a common goal and understand how a partnership between them could contribute significantly to the health of the people of Ghana."*
> **(Grameen Foundation 2011:45)**

Strategic leadership efforts should be focused on:

- Locating mHealth in a national and health sector E-Strategy which provides co-ordination and alignment of standards and projects. The starting point for any mHealth or eHealth policy is the strategic objectives of the health sector and a consideration of how these can be enhanced through use of ICT.
- Promoting a 'learning agenda' to build a national evidence base on mHealth, including a central repository for evidence on mHealth projects. Especially important is documentation on previous ICT projects that have failed due to implementation difficulties such as poor infrastructure and staff capacity.
- One of the key considerations for the effective application of mHealth is to what extent one is able to assess its effectiveness in terms of improved patient outcomes. This requires the existence of a well functioning Electronic Patient or Health Record that allows for the evaluation of longitudinal follow-up and outcomes of individual patient care. Nevertheless, despite the electronic health record being considered the cornerstone for effective application of ICT in health, there are few documented ICT projects in the health sector that can trace the impact of electronic patient records on improved health service delivery and improved health outcomes.

CURRENT SITUATION IN SOUTH AFRICA

- The South Africa government appears to be committed to promoting ICT as a support tool for government service delivery. On a national, provincial and municipal level, there are numerous examples of innovative use of electronic tools, the main example being e-filing of income tax returns in use by the South African revenue Services (SARS).
- The National Department of Health has embarked on the development of an eHealth strategy and a draft document was available as this review was being completed, in December 2011.

- Although not as yet using mobile phone technology, a variety of eHealth interventions have been implemented by government, including telemedicine, web-based health information systems (District Health Information Systems) and in the Western Cape, electronic patient health records. Evidence on the effectiveness of these eHealth interventions is not easily available - these are operational projects that were not necessarily accompanied by formal evaluations. There are indications that the experience with telemedicine has been mixed with close to 50% of projects having failed (Mars & Seebregts 2008). At the other end of the spectrum, the Western Cape Province DOH has won ICT awards for their patient electronic record systems (Mars & Seebregts 2008). NDOH is also currently implementing a national electronic medical record system for patients on antiretroviral (ARV) treatment.
- Mobile phone technology has been in used in smaller, mainly NGO and research based settings, as was shown in the case studies earlier in this report. The benefits from these smaller projects cannot easily be generalized to large-scale use of mHealth in the mainstream of health services.
- Larger scale mHealth projects are now being commissioned for implementation by various sectors of the health department, such as the Health Information System Programme (HISP)/Cell-life project for M&E of the HIV Counselling and Testing (HCT) campaign. The plan is to introduce over 10 000 mobile phones in a number of districts across the country to record data from the HCT register, into an electronic register. Another national project being proposed is the use of mobile phones for managing chronic care in a community based setting. A maternal and child health project known as MAMA, aimed at increasing antenatal visits via text messaging (using Text4Baby) is also in the pipeline.
- There still remains a gap with respect to building a national repository for evidence on the effectiveness of mHealth. Few projects are systematically evaluated and evaluations have been limited to assessing benefits compared to paper-based information management processes. Evidence is lacking on cost-efficiency, health systems impact and health outcomes.

2. Organisational systems: Is there a culture of and capacity for using information for management?

LESSONS LEARNT

The reviews suggest that eHealth projects could add more value if they are able to integrate with the larger context of health system activities and with strategic objectives of the health system. There are indications that ICT can aid development, but its scope and impact is dependent on other health systems factors. The social, organisational and cultural elements of implementing mHealth are often critical to the successful implementation of ICT. These can prove more challenging than the problems with the technology itself. mHealth should therefore be grounded in local realities of the country. Implementation plans may need to be focused on where the culture and capacity for effective implementation exist already. This should be accompanied by efforts to build capacity for information management and technology use as well as capacity for maintenance of ICT equipment.

Mobile phone technology, like any other technology has its limits in terms of being able to add value to a service delivery system. The way management views the utility

of mHealth could influence its successful adoption. One mistake is to view mobile technology as a magic bullet for fixing poorly functioning systems (for instance in monitoring, supervision, information management). To optimize the potential of mobile phones would require a comprehensive approach to service improvements- not only adequate equipment and training in ICT use, but also a focus on delivering quality clinical services and on maintaining a well functioning health system (including supply chain management and other support services). Efforts should include the strengthening of monitoring and evaluation capacity at various levels of health management-mHealth projects should be accompanied by systematic evaluations that are able to collect baseline data against which to compare outcomes.

Finally, when implementing mHealth, the aim is to balance the needs of all the stakeholders, but the usefulness for frontline users is critical. For effective and sustainable use of mobile technology, frontline users need to feel that the technology is useful for their work (be it through regular feedback loops, using it for communication or job aids or as an educational tool).

CURRENT SITUATION IN SOUTH AFRICA

- In South Africa, there is wide variation in the capacity and culture of using health information for management. Poor use of health information for management is evidenced in part by the poor health service delivery and health outcome indicators of the country.
- The culture of using information technology, such as computers and the internet, is not firmly entrenched in public sector primary health services. Further, there may also be challenges around the availability of technical skills for the maintenance of equipment and systems.
- Monitoring and evaluation of CBS in South Africa is generally considered an area of weakness due to the lack of adequate and standardized health information tools and processes, the lack of integration of information into existing routine health information system, the lack of dedicated M&E staff and budgets and the inadequate training at all levels. This raises questions about the likelihood of mHealth interventions being able to add value where the M&E systems are not functioning optimally.
- The mHealth4CBS case studies reviewed used mobile phone technology largely for data collection for research and monitoring of programme and staff productivity. Whilst managers and supervisors found it extremely useful for M&E, it is unclear to what extent they were able to use the rapid access to data as a tool for actual improvements in the process and outcomes of community based health care service delivery.

3. Technological systems: How user friendly and durable is the chosen technology?

LESSONS LEARNT

As this review has shown, modern ICT is capable of addressing many of the management needs required for improving current health service delivery. MHealth technology

is advancing rapidly with new applications constantly emerging. Health care decision makers therefore need to be knowledgeable enough about mHealth technologies to identify the key issues that would inform their technology and information system choices.

"For health care, interoperability enables data and technology systems to work together across organizational boundaries for better individual and community health. Attaining true interoperability requires significant coordination and cooperation among stakeholders. While experts today concur that consensus-based health care interoperability rules and standards are needed, many questions remain about how to achieve this in both developed and developing nations."
(The Rockefeller Foundation 2010:11)

The interoperability and alignment of technological, information and organisational systems should be prioritised. This means that current and new technology information systems should be able to share information easily with the rest of the information and systems architecture. Interoperability has multiple dimensions (see Box 1: Key steps towards interoperability) and require consensus amongst multiple stakeholders, which makes it much harder to achieve in practice:

The need for a common coding language and standards is important for interoperability within organisations and countries, but also for collaboration internationally. There is increasing recognition of the need for the global information technology community to subscribe to one form of computer language coding, such as for instance, HL7, to provide for interoperability of information systems on an international level. HL7 refers to Health Level Seven International - a global authority on standards for interoperability of health information technology.

Box 1: Key steps towards interoperability

- Understanding interoperability needs in an organizational, geographic and health system context
- Finding consensus among key interoperability stakeholders, such as patients, providers, health care facilities, ministries of health, districts, technology vendors, donors and development agencies
- Providing avenues for developing nations (which are largely absent in current standards development and interoperability discussions) to become more engaged
- Clearly articulating what technologies, policies, skills and leadership by government and industry are necessary to achieve interoperability
- Properly leveraging open, standards-based platforms and open-source collaborative models when needed

Extract from the Rockefeller report (The Rockefeller Foundation 2010:11)

There are other technological issues that need to be considered when making decisions about mHealth implementation:

- The hardware and software applications should be appropriate, flexible, user-friendly and durable. The choice of applications must to be balanced against the needs of the intervention and affordability. Some have referred to this balance as the "Goldilocks Zone"- where these competing requirements achieve just the right fit.
- Connectivity to power supplies, satellite transmission and internet bandwidth

should be reliable and affordable. The choice of type of mobile phone handsets has implications for use-ability and costs The general wisdom is to be 'device agnostic' as most entry level mobile phones (handsets) are capable of performing the basic requirement for a mHealth application. There should also be consideration of the environmental impact of choices of hardware and plans for re-use or disposing of unwanted equipment.

- There are no guidelines for interoperability standards for the country at present and SA does not have a local chapter of the HL7, which is one of the international standards being recommended.
- Interoperability can be facilitated by the use of affordable open-source software options in mobile phone technology, as these can promote collaborative development and sharing of software applications. The decision to use open-source versus proprietary software would be influenced to some extent by the availability of in-house or contracted trained personnel to design systems using open-source options, to provide the technical back-up and for the maintenance and expansion of systems.
- Finally, the need for privacy and security is a recurring concern amongst policy makers, planners and implementers (Rockefeller 2010). Whist technical solutions exist to restrict access to information and to secure the privacy of data, this may not be enough reassurance for many stakeholders involved in health care. The heightened concern may in part be due to the complex and private nature of health care and health care information, where a mix of role players need to access, to varying degrees, highly personal and confidential patient information in the course of a patient's treatment and potentially spanning a patients' lifetime. The issue took centre stage in a recent WHO report that surveyed eHealth legal frameworks of Member States of WHO, to determined the extent to which security and confidentiality of Electronic Health Records were in place (World Health Organization 2012). The report concluded that whilst most countries had regulations for general patient data, few (less than 10%) had specific regulations for protection of electronic health records, which they consider important as EHRs are becoming more common place.

CURRENT SITUATION IN SOUTH AFRICA

- South Africa has the most advanced mobile phone and internet industries in Africa, with a growing industry in the design and engineering of innovative mobile phone software applications for commercial and non-commercial use which provided fertile ground for local innovation around software development.
- Despite the very high levels of access to mobile-phone technology, the costs of telecommunications are still considered very high.
- Some have argued that South Africa still lags behind other LMICs with regards to the use of innovative ICT, such as in eHealth (Mars & Seebregts 2008). Rwanda is used as a comparison, where they have developed extensive systems to support ICT use in health.
- Government has expressed its support for the use of mHealth and is starting to promote its use. Decision-making for policy and health managers about implementing eHealth is however complicated by the need to strengthen a still relatively weak national health and management information system.
- The National Health Information Systems Committee of SA (NHIS/SA), committee of the NDOH, is active in providing policy guidance and co-ordination. An eHealth policy is emerging and is currently in a draft phase.

4. Financial systems: Is adequate financial provision being made for the medium to long term use of mHealth?

LESSONS LEARNT

The lack of financial sustainability is one of the key reasons for the failure of ICT projects in LMICs, where many ICT projects are funded by external donors and often do not have adequate funding to progress beyond the pilot stage. A related issue is that many of the pilot projects are not integrated into mainstream health systems and do no not have systematic impact evaluations, factors that further limit their financial sustainability.

Indications are also that ICT projects take longer to implement than was initially planned for and tend to cost much more than was budgeted for (Lucas 2008). Planners should anticipate this and do realistic financial planning.

A systems issue that have not received much attention in the literature, but that is also key to sustainable mHealth, is the issue of opportunity cost and how to assess this in the context of decision-making on mHealth. The decision whether to implement mHealth may need to be weighed up against other priority and evidence-based health systems interventions in terms of the costs and resources and capacity requirements for implementation, as well as its effect on either detracting from or supporting other interventions aimed at strengthening health systems.

CURRENT SITUATION IN SOUTH AFRICA

- In South Africa as elsewhere, smaller mHealth projects are largely donor funded and therefore vulnerable in terms of financial sustainability. Most of these projects do not have cost–effectiveness evaluations or information about the cost of up scaling.
- There is wide variation in how provincial health department spend funding allocated for ICT use (Mars and Seebregts 2008). This may be an indication of the variation across provinces in terms of their use of ICT- and perhaps of their capacity for funding and implementing future eHealth or mHealth projects.
- There is also strong commercial interest from private sector from ICT developers, which adds pressure on health sector decision-making about mHealth technology (Mars & Seebregts 2008).

Recommendations

One of the overarching lessons that can be drawn for this review is that the country and health systems context matters in the effective implementation of mHealth. In the South African context, the health system is not functioning as well as it should compared with other LMIC countries with the same or lower per capita input for health (Chopra et al. 2009). There is wide variation in the level of functioning of the health system across and within provinces in terms of the strength of their health systems functioning. This variation includes some provinces and districts with a stronger capacity for effective implementation of new information technology and with a stronger culture of using information for management for monitoring and evaluation and quality improvement.

In the absence of an overall strong capacity for effective implementation and use of health information technology and systems, and given the gaps in evidence on effectiveness of mHealth interventions, the overall recommendation for South Africa is that the health sector should not opt for full-scale implementation of mHealth for monitoring and evaluation of newly integrated community based Health care services. Rather, it is recommended that the health ministry should adopt a developmental approach to the implementation of mHealth. Government should promote a building blocks approach, encouraging the initial implementation of smaller, phased and heavily evaluated 'Lead 'or 'Lighthouse' projects within the routine organisational environment, paying attention to issues of end-user acceptability and interoperability with both technical and human resource systems. This will allow for growing the evidence base on mHealth in mainstream health settings as well as for building capacity for implementation and evaluation of mHealth interventions. These and further specific recommendations flowing from the proposed health systems framework are detailed below.

STEWARDSHIP

- The National and provincial departments of health should define what they consider a strategic leadership role in EHealth to be and to allocate responsibility for leading and co-ordination roles to the appropriate departmental agencies. The National Health Information System Committee of South Africa (NHIS/SA) is already active in addressing policy and practice challenges in health informatics and could play an ongoing role in promoting strategic leadership and collaboration for eHealth developments.
- Completing the eHealth policy or strategy (which should perhaps be inclusive of mHealth and telemedicine) is a priority. It should promote a supportive environment for learning more about the impact of eHealth and mHealth developments across various settings in South Africa, be it in research, NGO's, private sector or mainstream health services. It should also address the need to promote common standards and collaboration internationally and nationally around mHealth, whilst at the same time remaining flexible enough to respond to new evidence locally and internationally.
- As the health ministry is well on its way to developing a draft eHealth strategy, the next step would be to consult sufficiently widely with stakeholders to ensure that the strategy addresses the key organisational, technical, financial and stewardship issues (some of which have been outlined in this report).
- The NDoH should promote a learning environment and encourage the documenting of best practices. This could take the form of creating a central repository of

evidence on the impact, cost effectiveness and implementation barriers to mHealth in South Africa. This knowledge can then contribute to further development of the country's eHealth policies.

ORGANISATIONAL

- Taking a developmental and iterative approach to mHealth in SA, the health department should consider introducing mobile technologies into a limited number of well-established PHC outreach teams in a formative phase. This should be done with the view to both eliciting the full range of potential mHealth uses in the day-to-day work of teams and identifying the perceived value of the technology to the end-users.
- Intervention plans should be aligned with the objectives of the health department, and the outcomes should as far as possible be measured in terms of its impact on health systems strengthening and improving health outcomes. It is also recommended that any future mHealth interventions by government should ensure that an evaluation is done that starts with the collection of baseline data.
- Policy makers and managers should guard against viewing mobile phone technology as the intervention in itself- but rather view it as one of the support mechanisms for an evidence-based intervention (such as for example, using Text4Baby, as one tool in an intervention aimed at increasing antenatal visits). For this reason, business plans should outline how mobile technology will be able to support and enhance broader service delivery, how implementation processes will be managed and how impact and lessons about process will be evaluated. Effective implementation is key and managers should guard against mHealth proposals that do not look at all the health systems components required for effective implementation.
- It would be useful to develop simple tools to assess the e-readiness before implementing a mHealth project. In particular, the e-Readiness of PHC outreach teams should be assessed at baseline and the information used to design a common framework for evaluating government supported mHealth interventions. It should contribute knowledge on how to evaluate health system, cost and impact measures. On the basis of initial readiness assessments and trial implementation efforts, the implementers can then finalise the design and choices of the software and hardware to create the best possible 'fit' for all the stakeholders, and with special consideration of the use- ability for frontline users.
- It may be beneficial to use the services of expert business analysts in the field of mobile telecommunications and to build in a 'modeling' mechanism that can show on paper or through simulation, how the mHealth system would work in practice - even before making a final decision about implementation.

FINANCIAL

- In South Africa, the health ministry should require for any mainstream mHealth proposals to be accompanied by a business and financial plan that can realistically determine the costs and that can guide the implementation and evaluation processes.
- Financial stewardship should include generating sustainable funding for mainstream health service mHealth projects. It could involve promoting collaboration with and amongst external donor organisations, to promote building on existing government

mHealth initiatives, whilst also promoting enough flexibility for the testing of creative and innovative projects. In South Africa, such collaboration could help to limit the proliferation of stand-alone mHealth projects that fail due to lack of funding and promote projects that are linked in with mainstream government initiatives. The latter would presumably have realistic and sustainable funding.

- Increasing the affordability of mobile phone technology can contribute to increasing accessibility and sustainability of mHealth interventions. Financial stewardship should therefore involve negotiations with mobile phone networks to develop strategies to reduce costs of mobile telecommunications.

TECHNOLOGICAL

- In South Africa, it is recommended that National Health Information Systems of South Africa Committee (NHISSA) leads a process that draws on the full range of country expertise in mHealth software application development, and e-architecture, to develop a business case and guidelines for mHealth, that includes consensus on the following technological issues:
  - Guidance on interoperability should detail how information will flow through and link with the existing information systems, responsibility for operation of supervisory consoles and communication between outreach teams and clinics (including its links to the existing electronic DHIS).
  - The relative merits of open source versus proprietary software.
  - How the privacy and confidentiality of patient data will be ensured.
  - How connectivity and maintenance of technical systems will be ensured, including back up plans for power failures and failure of the technology.

Limitations of the review

This study was not a comprehensive review of projects using mHealth in SA, but rather a scoping exercise to get a sense of how mHealth is being employed in CBS. The strength of the project is that the experience and perceptions of different stakeholders were captured, including the views of providers of mHealth software applications. An inventory or full audit of all mHealth projects in South Africa would be useful to identify the varied uses and users of mHealth in South Africa.

Information of the cost efficiency of mHealth would have been useful for policy and decision-makers, but the study did not provide this. Gathering costing data would have required more in-depth investigation of case studies which was not feasible in the time frame of the review. Also, given the multiple factors affecting the implementation of mHealth, it would be premature to present costing scenarios for an up-scaled mHealth4CBS programme in South Africa.

The case studies were of small scale NGO and research projects because there are no large scale mainstream mHealth projects in SA. This limits the generalisability of the findings from the case studies. Reviews of mHealth in other LMICs therefore contributed a large portion of the evidence on the key lessons learnt. Finally, the study did not elicit the views of frontline users. It would be important to evaluate the experience of frontline users in current and future mHealth projects.

Conclusion

Against a background of increasing enthusiasm for the use of mobile phone technology in health services in LMICs, this study reviewed the potential usefulness of mHealth for monitoring and evaluation of the planned integration of community based health services in South Africa. The purpose was both to shed light on an emerging field and to provide recommendations for policy makers on the value of mHealth at scale, for the mainstream health services in South Africa.

The review methods included interviews with key informants and three local case studies of mHealth4CBS and a review of the literature on the use of mHealth in LMICs. The authors provided some definitional clarity and highlighted the benefits of mHealth as found in the case studies and literature. The report focused attention on a number of implementation challenges as well as gaps in evidence on the effectiveness of mHealth. The range of systems challenges identified in the literature raised the need for a health systems perspective when appraising the value of mHealth. The authors proposed such a health systems framework and using the case of South Africa, employed the framework to guide recommendations on mHealth for policy makers and managers.

In sum, it was recommended that against the background of gaps in evidence on effectiveness of mHealth at scale and the systems challenges with implementing mHealth, that South Africa needs to adopt a developmental approach to the implementation of mHealth, encouraging the implementation of smaller, phased and heavily evaluated 'Lead 'or 'Lighthouse' projects within the mainstream, routine health service environment. Specific recommendations that flow from the proposed health systems framework were detailed under the four health systems areas: stewardship, organisational systems, technological systems and financial systems.

The key contribution of this report is to provide policy makers and managers with a familiar health systems framework that both demystifies the mHealth arena and guides their decision-making and practice around mHealth implementation in South Africa. We would like to suggest that this health systems framework could be of value in other LMIC – to assist decision-makers in those settings.

Appendix

Table 4: Examples of community based health care projects using mobile-phone technology in Africa

Project types	Uses	Software applications
Malawi UNICEF and Columbia University, New York. A project for surveillance of child nutrition (UNICEF 2009)	Disease surveillance: Mobile phones to collect and transfer data on child growth measurements via SMS. CHWs got immediate confirmation of data submitted and alerts & directions if malnutrition identified.	RapidSMS Using an open-source software platform the data is received by a central server and automatically analyzed for indicators of child malnutrition.
Ghana Extracted from http://mobileactive.org/motech-new-approach-health-care 'In an effort to bridge the gap between community health workers and patients, the Grameen Foundation is in the midst of a two and a half-year project called Mobile Technology for Community Health or MoTeCH". (Grameen Foundation 2011; Mechael & Dodowa Health Research Center 2009)	" MoTeCH, a joint initiative between the Grameen Foundation, Columbia University's Mailman School of Public Health and the Ghana Health Service, is working to determine how best to use mobile phones to increase the quality and quantity of antenatal and neonatal care in rural Ghana."	"*MoTeCH uses OpenMRS, an open source medical record system as the basis of the medical records management, while the rest of the software is uniquely designed for MoTeCH by developers*"
Tanzania Supervision of community health care workers (DeRenzi et al. 2011b)	The study evaluated the impact of SMS reminders to improve the promptness of routine CHW visits, first in a pilot study in Dodoma, Tanzania, followed by two larger studies with 87 CHWs in Dar es Salaam, Tanzania	RapidSMS

References

Alam, M., Khanam, T., Khan, R., Raihan, A. & Chowdhury, M. (2010) Assessing the scope for use of mobile based solution to improve maternal and child health in Bangladesh: A case study on efficiency of community health workers, automated risk assessment of patients and web based data collection. ICTD 2010 London Conference.

Ali, M. & Bailur, S. (2007) The Challenge of "Sustainability" in ICT4D-Is Bricolage the answer? São Paulo, Brazil Proceedings of the 9th International Conference on Social Implications of Computers in Developing Countries.

Armstrong, A. W., Watson, A. J., Makredes, M., Frangos, J. E., Kimball, A. B. & Kvedar, J. C. (2009) Text message reminders to improve sunscreen use: a randomized, controlled trial using electronic monitoring. Arch. Dermatol., 145(11): 1230-1236.

Avgerou, C. & Walsham, G. (2000) Information technology in context : Studies from the perspective of Developing Countries. Aldershot, Ashgate.

Batchelor, S., Evangelista, S., Hearn, S., Peirce, M., Sugden, S. & World), M. W. B. (2003) ICT for Development Contributing to the Millennium Development Goals: Lessons Learned from Seventeen infoDev Projects. Gamos Ltd.

Black, A. D., Car, J., Pagliari, C., Anandan, C., Cresswell, K., Bokun, T., McKinstry, B., Procter, R., Majeed, A. & Sheikh, A. (2011) The impact of eHealth on the quality and safety of health care: a systematic overview. PLoS Med, 8(1): e1000387.

Bukachi, F. & Pakenham-Walsh, N. (2007) Information Technology for Health in Developing Countries. American College of Chest Physicians.

Chen, Z. W., Fang, L.Z., Chen, L.Y., Dai, H.L. (Jan 2008) Comparison of an SMS text messaging and phone reminder to improve attendance at a health promotion center: a randomized controlled trial. J. Zhejiang Univ. Sci. B.

Chetley, A. (2006) Improving health, connecting people:the role of ICTs in the health sector of developing countries: A framework paper. InfoDev

Chopra, M., Lawn, J. E., Sanders, D., Barron, P., Abdool Karim, S. S., Bradshaw, D., Jewkes, R., Abdool Karim, Q., Flisher, A. J., Mayosi, B. M., Tollman, S. M., Churchyard, G. J. & Coovadia, H. (2009) Achieving the health Millennium Development Goals for South Africa: challenges and priorities. Lancet, 374(9694): 1023-31.

Clarke, M., Schoeman, H. & Friedman, I. (2007) Towards a generic surveillance system to measure the impact of Community Health Worker programmes in South Africa: a comparison of paper-based and mobile/cell phone methods. Durban Heath System Trust.

DeRenzi, B., Borriello, G., Jackson, J., Kumar, V. S., Parikh, T. S., Virk, P. & Lesh, N. (2011a) Mobile Phone Tools for Field-Based Health care Workers in Low-Income Countries. Mount Sinai Journal of Medicine: A Journal of Translational and Personalized Medicine, 78: 406-418.

DeRenzi, B., Findlater, L., Borriello, G., Jackson, J., Payne, J., Birnbaum, T., Parikh, T. & Lesh, N. (2011b) Improving Community Health Worker Performance Through Automated SMS. unpublished.

deTolly, K., Nembaware, V. & Skinner, D. (2011a) Encouraging HIV testing through SMS: Can it work, and do content and dosage impact? SA AIDS Conference, Durban.

deTolly, K., Technau, K.-G. & Benjamin, P. (2011b) Helping HIV+ mothers protect their babies: Improving follow-up and HIV testing rates of exposed infants through SMS. SA AIDS Conference, Durban.

Fairhurst, K. & Sheikh, A. (2008) Texting appointment reminders to repeated non-attenders in primary care: randomised controlled. Qual. Saf. Health. Care, 17(5): 373-376.

Florez-Arango, J. F., Iyengar, M. S., Dunn, K. & Zhang, J. (2011) Performance factors of mobile rich media job aids for community health workers. Journal of the American Medical Informatics Association: JAMIA, 18(Mar): 131-137.

Free, C., Knight, R., Robertson, S., Whittaker, R., Edwards, P., Zhou, W., Rodgers, A., Cairns, J., Kenward, M. G. & Roberts, I. Smoking cessation support delivered via mobile phone text messaging (txt2stop): a single-blind, randomised trial. Lancet, 378(9785): 49-55.

Gagnon, M., Légaré F, Labrecque M, Frémont P, Pluye P, Gagnon J, Car J, Pagliari C, Desmartis M, Turcot L & Gravel K (2009) Interventions for promoting information and communication technologies adoption in healthcare professionals (Review). The Cochrane Collaboration.

Grameen Foundation (2011) Mobile technology for community health in Ghana: What it is and what Grameen Foundation has learned so far. New York, Columbia University.

Hilbert, M. & Lopez, P. (2011) The world's technological capacity to store, communicate, and compute information. Science, 332(6025): 60-5.

Ivatury, G., Moore, A. & Bloch, A. (2009) A Doctor in Your Pocket: Health Hotlines in Developing Countries. Innovations: Technology, Governance, Globalization, 4(1): 119-153.

James, T., Lähde, K., Naidoo-Swettenham, T. & McKay, K. (2011) A Practical Approach to ICT for Development: Perspectives from the SAFIPA Programme. Pretoria, CSIR Meraka Institute, South Africa.

Khoya, S., Scott, R. E., Casebeer, A. L., Mohsin, M., Ishaq, A. F. M. & Gilani, S. (2007) e-Health Readiness Assessment Tools for Healthcare Institutions in Developing Countries. Telemedicine and e-Health, 13(4).

Labelle, R. (2005) ICT Policy Formulation and e-Strategy Development: A Comprehensive Guidebook. United Nations Development Programme-Asia Pacific Development Information Programme (UNDP-APDIP).

Lehmann, U. & Sanders, D. (2007) Community health workers: What do we know about them? Geneva, WHO: Evidence and Information for Policy, Department of Human Resources for Health.

Lester, R. T., Mills, E. J., Kariri, A., Ritvo, P., Chung, M., Jack, W. & al., e. (2009) The HAART cell phone adherence trial (WelTel Kenya1): a randomized controlled trial protocol. Trials, 10(87).

Lobach, D. F., Low, R., Arbanas, J. A., Rabold, J. S., Tatum, J. L. & Epstein, S. D. (2001) Defining and supporting the diverse information needs of community-based care using the web and hand-held devices. Proc AMIA Symp: 398-402.

Lucas, H. (2008) Information and communications technology for future health systems in developing countries. Soc Sci Med, 66(10): 2122-32.

Mars, M. & Seebregts, C. (2008) Country Case Study for eHealth: South Africa. Rockefeller Foundation. www.rockefellerfoundation.org/.

Mechael, P., Batavia, H., Kaonga, N., Searle, S., Kwan, A., Goldberger, A., Fu, L. & Ossman, J. (2010) Barriers and Gaps Affecting mHealth in Low and Middle Income Countries: Policy White Paper. New York, Center for Global Health and Economic Development Earth Institute, Columbia University.

Mechael, P. & Dodowa Health Research Center (2009) MOTECH:mHealth Ethnography Report. New York, Grameen Foundation.

National Department of Health (2011) Primary Health Care re-engineering document. Pretoria, Government of South Africa.

Ogunmefun, C., Friedman, I., Mothibe, N. & Mbatha, T. (2011) A national audit of home and community-based care (HCBC) organisations in South Africa. AIDS Care, 1(8).

Ogunmefun, C., Mothibe, N. & Friedman, I. (2010) Electronic Community Care Giver (CCG) Study: A summative evaluation of the implementation of an Electronic Monitoring and Evaluation Solution for CCG programmes. Durban, Health Systems Trust.

Pisasale, C. & Holt, A. (2009) Telehealth in the Developing World. IN Wootton, R., Patil, N. G., Scott, R. E. & Ho, K. (Eds.) Book review. Royal Society of Medicine, Press/ IDRC

Rowe, A. K., deSavigny, D., Lanata, C. F. & Victora, C. G. (2005) How can we achieve and maintain high-quality performance of health workers in low-resource settings? The Lancet, 366(Sep): 1026-1035.

Rowe, A. K., Onikpo, F., Lama, M., Osterholt, D. M., Rowe, S.Y. & Deming, M. S. (2009) A multifaceted intervention to improve health worker adherence to integrated management of childhood illness guidelines in Benin. American Journal of Public Health,, 99(May): 837-846.

Seebregts, C. J., Zwarenstein, M., Mathews, C., Fairall, L., Flisher, A. J., Seebregts, C., Mukoma, W. & Klepp, K. I. (2009) Handheld computers for survey and trial data collection in resource-poor settings: development and evaluation of PDACT, a Palm Pilot interviewing system. Int J Med Inform, 78(11): 721-31.

Skinner, D., Rivette, U. & Bloomberg, C. (2007) Evaluation of use of cellphones to aid compliance with drug therapy for HIV patients. AIDS Care, 19(5): 605-607.

The Rockefeller Foundation (2010) From Silos to Systems: An Overview of eHealth's Transformative Power. New York, Rockefeller Foundation.

Tomlinson, M., Solomon, W., Singh, Y., Doherty, T., Chopra, M., Ijumba, P., Tsai, A. C. & Jackson, D. (2009) The use of mobile phones as a data collection tool: a report from a household survey in South Africa. BMC Med Inform Decis Mak, 9: 51.

Treatman, D. & Lesh, N. (2011) Strengthening Community Health Systems with Localized Multimedia. Charlestown, MA, USA, Dimagi Inc.unpublished.

UNICEF (2009) Using Mobile Phones to Improve Child Nutrition Surveillance in Malawi. UNICEF Malawi and UNICEF Innovations.

Vital Wave Consulting (May 2009) Health Information Systems in Developing Countries : A Landscape Analysis. Vital Wave Consulting

WHO (2005) The Fifty-eighth World Health Assembly (WHA58.28 eHealth): Resolutions and decisions. Geneva.

World Health Organization (2012) Legal frameworks for eHealth. Geneva, WHO.

Wouters, B., Barjis, J., Maponya, G., Martiz, J. & Mashiri, M. (2009) Supporting Home Based Health Care in South African Rural Communities Using USSD Technology. San Francisco, California

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