Value of a mobile information system to improve quality of care by community health workers

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Background: We will be unable to achieve sustained impact on health outcomes with community health worker (CHW)-based interventions unless we bridge the gap between small scale efficacy studies and large scale interventions. Effective strategies to support the management of CHWs are central to bridging the gap. Mobile phones are broadly available, particularly in low and middle income countries (LAMIC), where the penetration rate approaches 100%.

Objectives: In this article, we describe how mobile phones and may be combined with mobile web-based technology to assist in the management of CHWs in two projects in South Africa.

Methods: This article is a descriptive study, drawing lessons from two randomised controlled trials outlining how a mobile phone information system can be utilised to enhance the quality of health interventions. We organised our comprehensive management and supervision system around a previously published management framework. The system is composed of mobile phones utilised by CHWs and a web-based interface utilised by CHW supervisors. Computerised algorithms were designed with intervention and assessment protocols to aid in the real-time supervision and management of CHWs.

Results: Community health workers used mobile phones to initiate intervention visits and trigger content to be delivered during the course of intervention visits. Supervisors used the web-based interface for real-time monitoring of the location, timing and content of intervention visits. Additional real-time support was provided through direct support calls in the event of crises in the field.

Conclusion: Mobile phone-based information system platforms offer significant opportunities to improve CHW-delivered interventions. The extent to which these efficiency gains can be translated into realised health gains for communities is yet to be tested.

Introduction

With the health budgets of more than 40 African nations spending less than $30 per person annually, it is critical that more cost-effective delivery strategies are identified for health care (Lewin *et al*. 2008). The personnel necessary for serving the health care needs for HIV-related diseases cannot feasibly be met until the year 2050 (Anyangwe & Mtonga 2007). Therefore, community health workers (CHWs) are increasingly identified as a potential vehicle for strengthening community based care; especially for maternal, newborn and child survival. Whilst successful CHW programs alone will not solve the maternal and child health crises facing many poor countries, they have the potential to make a large impact by significantly expanding access to healthcare (Haines *et al*. 2007).

Healthcare systems in many African and South Asian countries currently utilise CHWs in their programs as part of their plan to achieve the Millennium Development Goals and other human development priorities (Haines *et al*. 2007). It is estimated that there are more than 40 million CHWs around the world at present (Lewin *et al.* 2010). Several trials have shown the efficacy of CHWs in reducing morbidity and mortality amongst neonates and infants (Bang *et al*. 2005; Sazawal & Black 2003; Manandhar *et al*. 2004). However, most research evaluating the impact of CHW programs has been limited to small and short-term interventions in heavily resourced research settings (Haines *et al*. 2007). Larger scale CHW programs such as the national implementation of the Integrated Management of Childhood Illness strategy in Peru (Huicho

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Note: †, Dr Mark Colvin passed away on 31 January 2012.

et al. 2005), and the national CHW program in Sri Lanka (Walt *et al.* 1989) have been hindered by barriers to effective scaling up. Large scale programs are frequently undermined by high attrition and low activity levels of CHWs, which are less likely in smaller scale initiatives where supervision is often more intense and consistent (Walt *et al.* 1989). Whilst the use of CHWs has achieved many successes (Baqui *et al.* 2008; Rahman *et al.* 2008), the system has also been characterised by a lack of consistent supervision and linkages to the health system (Walley *et al.* 2008; Haines *et al.* 2007).

We will be unable to achieve sustained impact utilising CHWs unless we can bridge the gap between small scale efficacy studies and large scale interventions. An important part of this process lies in building effective strategies to support the management and supervision of CHWs (Rowe *et al.* 2005). The performance of CHWs in achieving their health objectives is influenced by multiple factors, but it is widely accepted that effective management is of fundamental importance (Rowe *et al.* 2005; Gray & Ciroma 1988; Haines *et al.* 2007; Kelly *et al.* 2001; Walt *et al.* 1989). The difficulties in establishing an effective information system that provides managers with high quality and timely information about the activities and performance of a dispersed group of workers may be an important cause of the loss of quality in information and supervisory systems as programs scale up.

South Africa has over 60 000 CHWs most of whom are paid by national government but are employed, monitored, and evaluated by non-governmental organisations (NGOs). The National Department of Health in South Africa is currently implementing a Primary Health Care revitalisation strategy, where community-based outreach functions are being prioritised and funded based on a large extent Brazil's Family Health Program (Paim *et al.* 2011). Primary health care teams are currently being implemented in South Africa, and linked to a local health facility and staffed by community health workers and nurses (National Department of Health 2011). Central to this re-vitalisation process is improving the management of CHWs and a renewed commitment to the use of Information and Communication Technology and particularly mobile phones in this process (Leon & Schneider 2011).

The rapid technological innovation in the mHealth (which are interventions categorised under the rubric 'mobile health' or 'mHealth' are broadly defined as medical and public health practice supported by mobile devices (Van Heerden *et al.* 2012). The mHealth field has led to a proliferation of untested methods and small-scale projects. This has recently begun to change with studies showing the potential impacts of scaling up using mHealth innovations (Zurovac *et al.* 2011). The implementation of mobile phone information systems has the potential to provide practical and simple solutions to management difficulties at scale. With more than 5.3 billion mobile phones in use, there is an organically created information platform that can rapidly disseminate innovations in health care (Tomlinson *et al.* 2009). In this article, we draw on our experience over the last six years to describe a system we developed and to suggest ways in which this information platform can be used to improve the supervision, management and quality of interventions provided by CHWs.

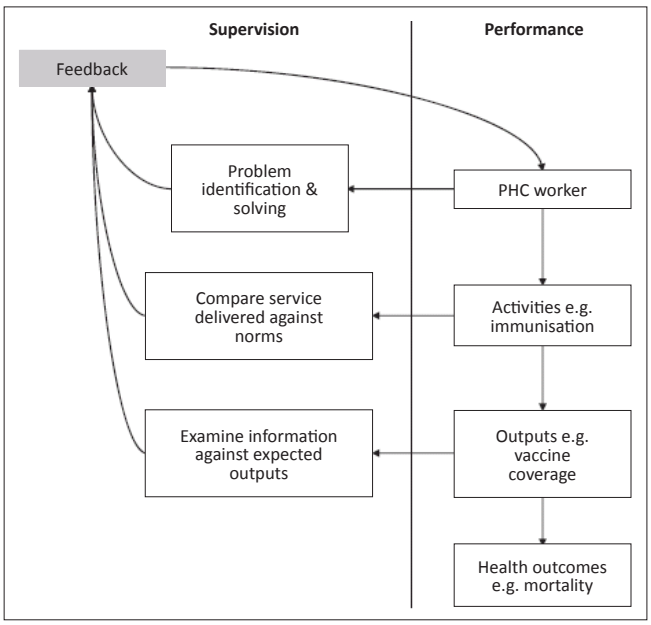
Methods

Management of community health care workers

CHWs are effective when there is an effective health system or NGO that provides supervision, supplies, monitoring and on-going training. However, organising these critical support activities at scale has proven very difficult. Our mobile information system was based on a previously published framework (Bosch-Capblanch & Garner 2008). Their model (see Figure 1) links health care worker performance including activities of the CHW (counseling, education), outputs (coverage) and outcomes (morbidity) with aspects of management such as comparing service delivered against norms, problem identification and examining data against expected outputs. This model is in line with the work of Rowe and colleagues who have outlined a number of typical reasons for the inadequacy of supervision of CHWs at scale (Rowe *et al.* 2010). These include poor co-ordination, inadequate management skills, problems related to decentralisation, increasing supervision workload, time required for supervision activities, lack of transportation, insufficient knowledge of how to plan visits and a lack of tools to assess supervision (Rowe *et al.* 2010).

Our mobile information system

In partnership with a private, South Africa-based digital company (Clyral) we have developed a comprehensive information and supervision system that combines mobile phones with a web-based information interface. Our primary



Source: Bosch-Capblanch, X. & Garner, P., 2008, 'Primary health care supervision in developing countries', *Tropical Medicine International Health* 13, 369–383. http://dx.doi.org/10.1111/j.1365-3156.2008.02012.x

FIGURE 1: The framework for supervision.

motivation was to develop a system of daily monitoring of CHW visits to aid in the supervision of a large cadre of CHWs. Specific focus areas (all of which are central to supervision [Rowe *et al*. 2010]) for the system were:

1. recruitment of study mothers, CHW assessment, and adaptive scheduling and visit planning
2. intervention delivery support, fidelity monitoring and individual case monitoring
3. caseload reporting and information management. (n.p.)

The system was designed to integrate all CHW activities into a web-based information narrative that is initiated the moment a participant is recruited; all intervention and data milestones are triggered automatically. Computerised algorithms have been designed to monitor and trigger the intervention and assessment protocols to aid in the real-time supervision and management of CHWs. These protocols include assessment of intervention fidelity, quality control, visit planning, and monitoring of CHW productivity. The web based information system was developed in partnership with a private digital company in South Africa, Clyral. Our system imposes few requirements with regards to the specific handset models to be used. The single requirement is that they need to be enabled for Java programming (Tomlinson *et al*. 2009). All of the CHWs were women with no previous administrative or data collection experience, but all had previous experience using basic mobile phone functions such as making calls and sending SMSs. Training CHWs in the use of the mobile phone application consisted of a one day training workshop, followed by several one hour refresher courses throughout the duration of the project. We also implemented weekly face-to-face group supervision, with individual supervision when necessary. Each CHW was supplied with her own project mobile phone.

Results

Recruitment, assessment, and adaptive scheduling and planning

We have been working with local CHWs in two projects in South Africa to explore how mobile-information-based supervision could be used to improve supervision and management of CHW's (see Box 1). In both projects, CHWs recruit expectant mothers in clusters through door-to-door home visits. The global positioning system (GPS) captures the geographical coordinates on the CHW's mobile phone for each household visited. As a CHW enters a household, the CHW begins monitoring the visit duration with a single click on the phone. Then, as she leaves the home at the end of the intervention visit, she repeats the click on the phone. The GPS- and time- stamping functions are built into each mobile phone, allowing the location and duration of the household visit to be assessed and transferred in real-time to the web-based information, supervision and management system. The GPS function reduces the possibility of falsifying data substantially, as the time between visits and the location of the visit is automatically recorded and transmitted to the CHW supervisors. Compared to systems implemented in prior studies, the lag time between protocol deviations (by CHWs) and triggering of reactive monitoring (by supervisors) is thereby substantially reduced. Similar advantages exist for the assessment of interviewers and recruiters in research trials.

Once a woman is enrolled in the program, a short intake questionnaire is completed using the mobile phone. This information includes her personal details, selected health information, gestation and risk profiling. Once received by the central web based program, the system combines the woman's expected date of delivery with an algorithm for her health information to determine her relative level of risk. Based on the result, the system determines the quantity and scheduling of antenatal visits that she is required to receive from the CHW before her infant is born.

After the birth of each participant's child, the system schedules the quantity and timing of her postnatal visits. A woman who is assessed to be at high risk (e.g. if she gives birth to an infant of low birth weight) is assigned to receive more home visits than a woman who is considered low risk. At present, this process occurs through a manual case consultation process rather than occurring automatically according to an algorithm loaded on the mobile phone (but the system can be designed so that this process is automated). Once this decision has been made, the information system automatically schedules and follows up on these 'extra visits'.

For each visit that a participating mother is due to receive, a dated milestone is created on her participant page in the web-based information console (see Figure 2). The dated visit milestones for all mothers in the program filter through

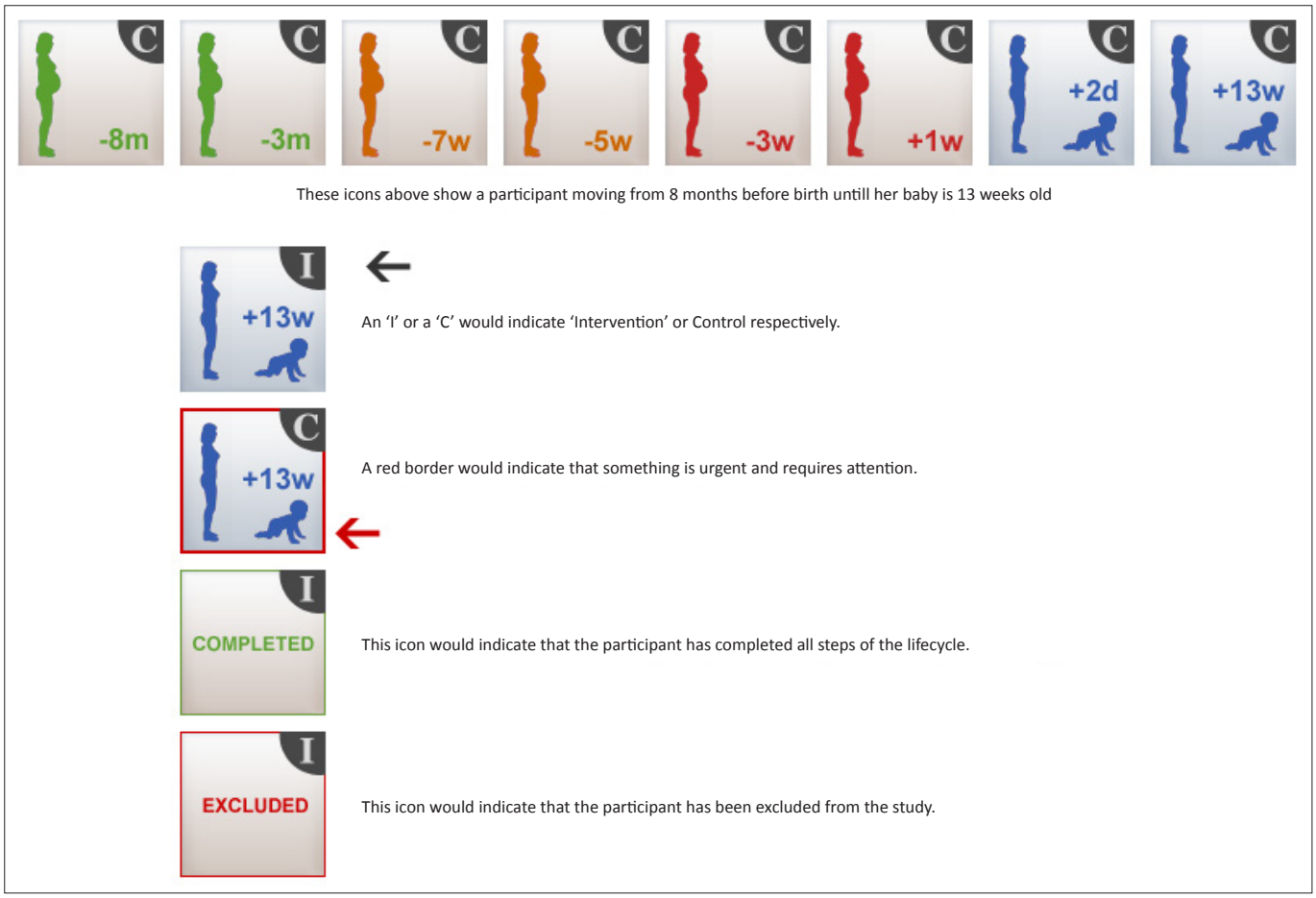
BOX 1: Two case studies: Goodstart 3 and Philani Mentor Mothers Project.

Goodstart 3

The Goodstart 3 study is a cluster randomised controlled trial being implemented in Umlazi, a peri-urban settlement close to Durban in South Africa with a population of approximately 1 million. The 2010 antenatal HIV prevalence in this district was 41% (SANDOH 2010) and infant mortality is estimated to be 42 per 1000 live births (Day *et al*. 2011). Mobile phone connectivity in Umlazi is excellent. The goal of Goodstart 3 study is to develop, evaluate and cost an integrated and scalable home visit package delivered by CHW's targeting pregnant and postnatal women and their newborns to provide essential maternal or newborn care as well as interventions for Prevention of Mother to Child Transmission (PMTCT) of HIV. Umlazi has a mixture of formal and informal housing, and whilst it is a relatively well-resourced peri-urban area; it has a non-optimally functioning health system. South Africa is one of twelve countries worldwide where child mortality has increased since 1990 (Bradshaw *et al*. 2008). This is primarily related to the HIV epidemic, with more than half of child deaths attributed to HIV and AIDS (Liu *et al*. 2012). The evaluation trial consists of 30 randomised clusters (15 in each arm) of the population. Results from this study are forthcoming.

The Philani Mentor Mothers Project

The Philani Mentor Mothers Project) is a longitudinal, cluster-randomised controlled trial. The study was conducted in Khayelitsha, a peri-urban settlement of approximately one million people, on the outskirts on Cape Town, South Africa. Khayelitsha, like many South African township settings, has high levels of violence, with poor infrastructure, vast areas of informal houses (shacks), and high levels of unemployment (Nleya & Thompson 2009). Mobile phone connectivity in Khayelitsha is excellent. The project aims to evaluate the effectiveness of a home-based care intervention delivered by CHWs for preventing and managing illnesses related to HIV, TB, alcohol use and malnutrition in pregnant mothers and their infants. The study has 1200 mothers in 24 neighbourhood clusters, 12 of which are intervention neighbourhoods, and 12 of which are control neighbourhoods. A cohort of women from each neighbourhood is followed from pregnancy until their infants are 18 months old. The home visits are designed to be both supportive and educational in nature. They are intended to empower pregnant mothers to better protect the health of their families by accessing available clinic services, implementing preventive behaviours in daily life routines, and sustaining preventive behaviours over time. The home-based delivery strategy addresses the cluster of behaviours necessary to deal with chronic conditions simultaneously, as opposed to individually (Le Roux *et al.* 2013).



Source: Mobenzi Researcher n.d., *Philani Mentor Mothers Project*, viewed from http://www.mobenzi.com/researcher/Case-Studies/View/Philani-Mentor-Mothers-Project; Mobenzi Researcher n.d., *Good Start III* (*Saving Newborn Lives*), viewed from http://www.mobenzi.com/researcher/Case-Studies/View/Good-Start-III-(Saving-Newborn-Lives)

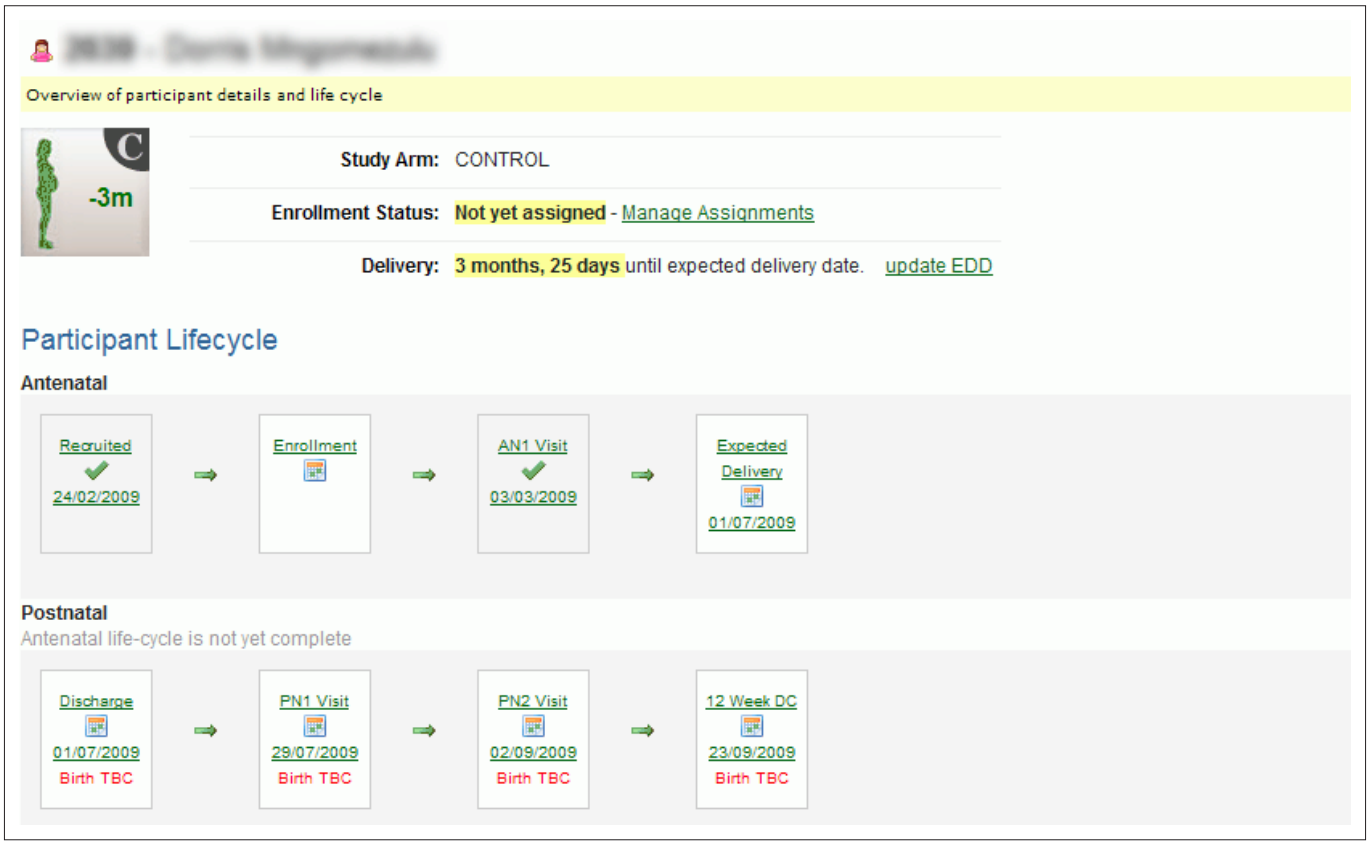
FIGURE 2: The icons on web-console.

to a weekly timetable for each CHW. This timetable details which mothers she needs to visit that week (see Figure 3). At each visit, the CHW records the duration and content of the visit on her mobile phone, which ticks off each milestone in the participant's lifespan as completed. Once completed, the visit reminder is removed from the weekly timetable. As can be seen from Figure 3, before the birth of the infant the console simply reflects antenatal visits completed thus far. The postnatal visits are portrayed as to be completed. As soon as the woman gives birth, the birth date and time is entered into the mobile phone and transferred to the web-based system, which automatically schedules and triggers all postnatal visits. Simultaneously, the CHW and the CHW supervisor receive an SMS notification of the birth and the dates of all scheduled visits.

The GPS co-ordinates of each household could also be used in such a way that within each week, those mothers who live closest to each other are scheduled for appointments on the same day. This system could minimise the distance the CHW needs to travel each day and improve the efficiency of the time they spend in the field. Currently, the specific set ups used in our studies do not co-ordinate at this level of detail. However, the underlying computer code for the mobile information system has been structured so that significant changes to its function and content can be made, depending on the particular requirements of the specific project. The GoodStart 3 study for instance is aimed at reducing neonatal mortality and improving levels of exclusive and appropriate feeding. As a result, visits are highly structured with a particular emphasis on visits occurring at particular times in the early neonatal period (e.g. 24 hours to 48 hours and 3 days to 4 days after birth) (see Figure 3). In the Philani study on the other hand, visits are less structured - in terms of both the day on which visits must take place and the time taken for each visit. To monitor both the date of visit and time spent (per visit and across time), we developed an interface that included a cumulative time counter (comparable to an egg timer) (see Figure 4). By tracking visit duration (and total time spent on the intervention), we are able to characterise the potentially dose-dependent response to the intervention, as well as calculate intervention delivery costs in a more precise way.

Intervention delivery support, fidelity monitoring and individual case monitoring

A significant difficulty when scaling up interventions is the issue of intervention fidelity and how to ensure quality control of intervention delivery. We developed a series of short questionnaires that were triggered on the mobile phones when the CHW entered the identification number



Source: Mobenzi Researcher n.d., *Philani Mentor Mothers Project*, viewed from http://www.mobenzi.com/researcher/Case-Studies/View/Philani-Mentor-Mothers-Project; Mobenzi Researcher n.d., *Good Start III* (*Saving Newborn Lives*), viewed from http://www.mobenzi.com/researcher/Case-Studies/View/Good-Start-III-(Saving-Newborn-Lives)

FIGURE 3: The intervention schedule.

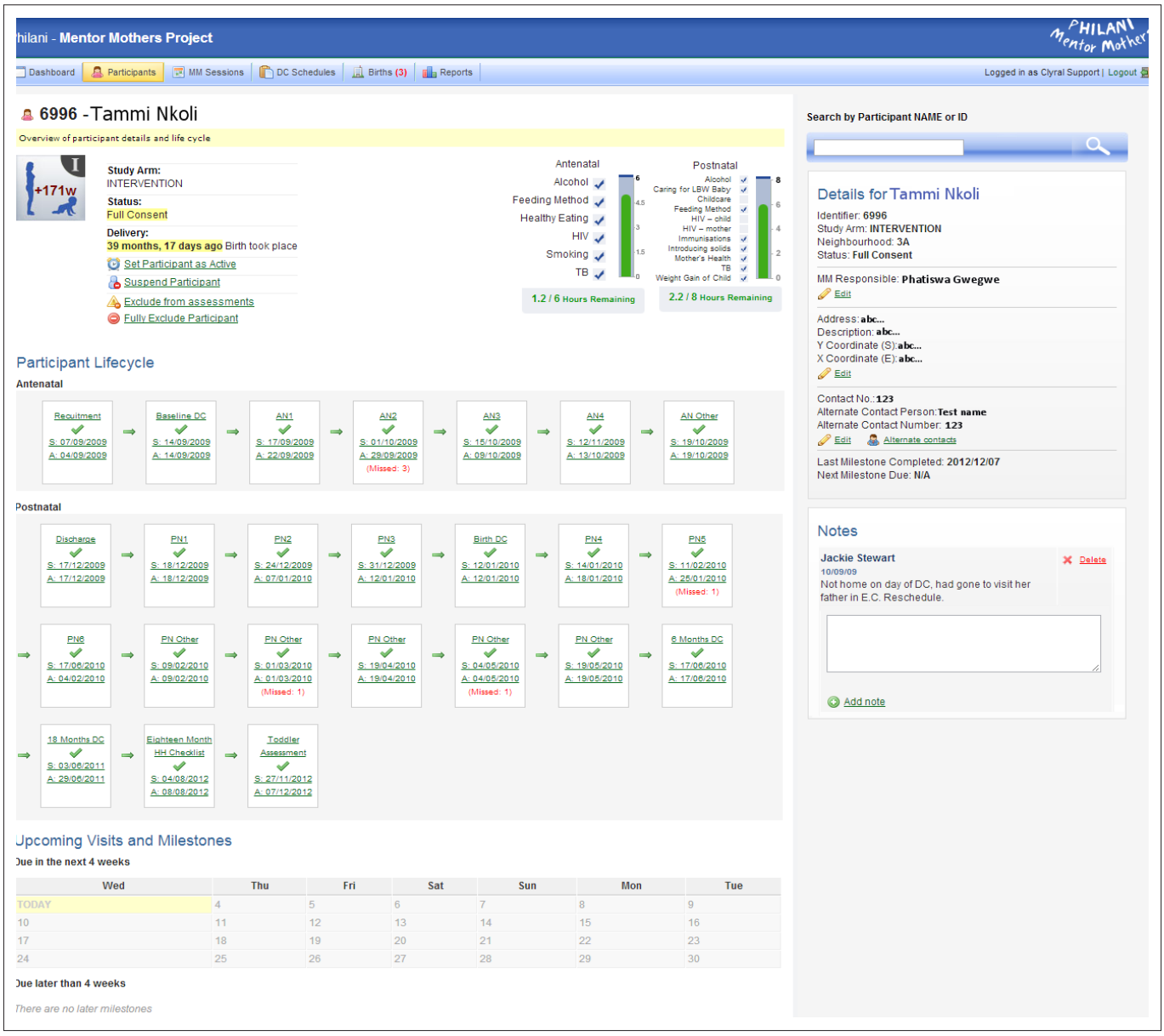
of the household being visited. This questionnaire serves as a reminder about the core intervention messages to be covered at that visit, a check on intervention fidelity that the topics were covered, and as the data source for the adaptive scheduling of follow up visits and intervention content. Antenatal questions include whether the woman has made a booking at the antenatal clinic; what her feeding plan is and whether she has been tested for HIV. Postnatal questions include questions about maternal and neonatal illness; whether the baby received AZT; whether the mother went to the clinic at six days post-birth; breast health; whether the infant has been tested for HIV; and if babies are HIV-positive, whether they are receiving cotrimoxazole.

To account for day-to-day participant availability, the system allows a CHW to suspend a visit based on the availability of the participant. If the CHW determines that she should return to complete a visit at some other time in the future, she can tick the appropriate box on the mobile phone. Her tick is immediately registered on the web based system. This is also the case for missed visits (participant not home when CHW arrives) or visits cut short for other reasons (e.g. an irritable infant). In this way, the system is able to monitor all aspects of the intervention such as CHW caseloads, clusters with higher levels of missed visits compared to other clusters; reasons for missed or suspended visits; and CHW performance in real time on a daily basis. The web-based management system (and mobile-phone connectivity) allows supervisors to (remotely) access the information console and monitor real-time information about each participating mother and child in the intervention program, as well as information on each CHW's activities and caseloads.

The console has a live report of all visits that have taken place, which can be filtered by date and by CHW, to establish how many visits are happening on any given day or week by any given CHW. The console also generates a 'visit-time' report (see Figure 5), with details for each participant in the intervention; not only how many visits they have had, but also the cumulative amount of time for all visits combined. In this way, one can easily identify outliers amongst participants or amongst CHWs. Based on these reports, together with the system flags that are generated, supervisors are able, in real time, to schedule a 'shadow' or 'spot' visit for the supervisor to conduct checks on the quality of home visits. In addition, visits are randomly generated and scheduled based on each weekly schedule for each CHW. These visits allow the supervisor to validate the observational reports of the CHW or identify households which should receive extra support.

The system can be used to optimise supervision at every level of the intervention program including:

- recruitment and scheduling of visits
- monitoring activity and progress of CHWs
- managing health information and emergencies
- accessing data such as date of visit to household and duration of visit



Source: Mobenzi Researcher n.d., *Philani Mentor Mothers Project*, viewed from http://www.mobenzi.com/researcher/Case-Studies/View/Philani-Mentor-Mothers-Project; Mobenzi Researcher n.d., *Good Start III* (*Saving Newborn Lives*), viewed from http://www.mobenzi.com/researcher/Case-Studies/View/Good-Start-III-(Saving-Newborn-Lives)

FIGURE 4: The participant dashboard.

- provide knowledge of visit schedule
- pinpoint discrepancies and anomalies automatically with alerts sent to supervisors.

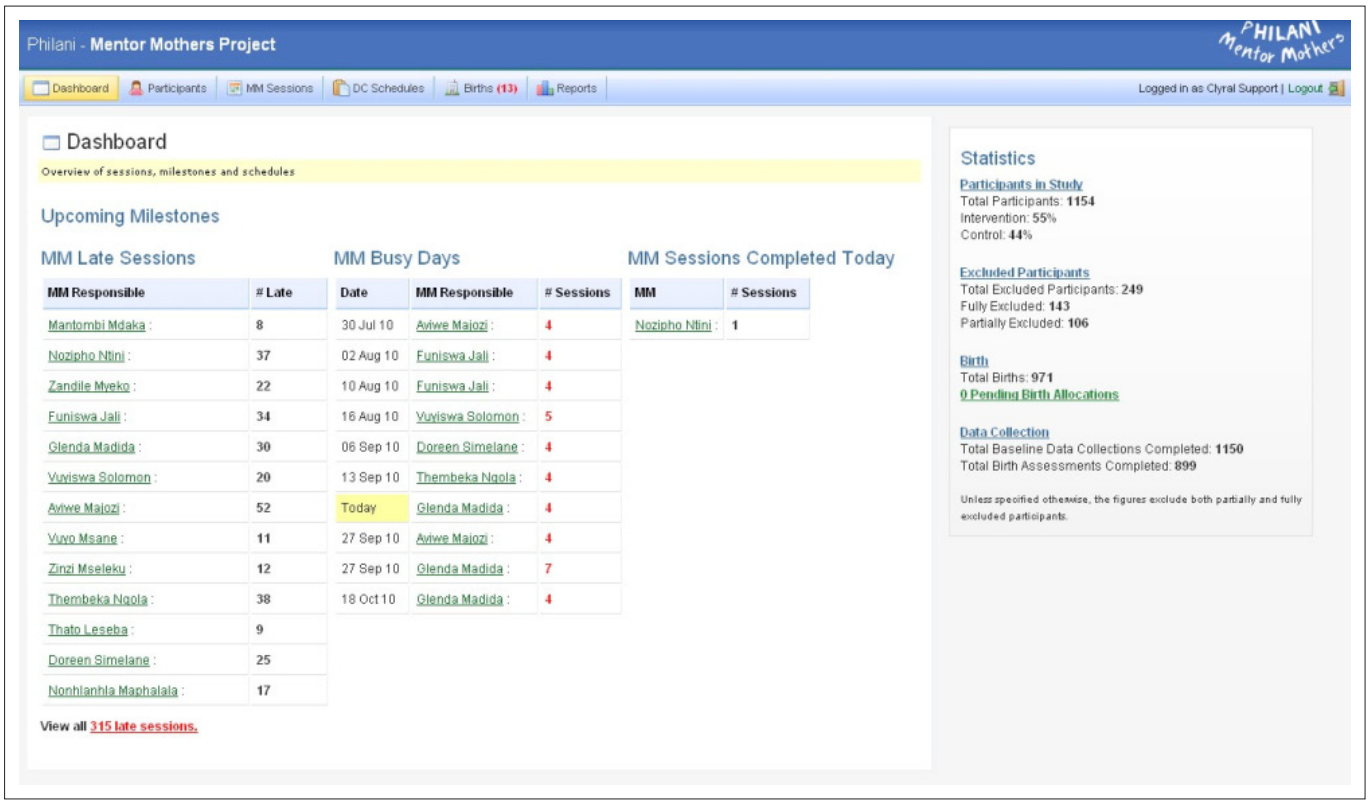
For instance, a visit of very short duration in the first 48 hours of birth will be flagged as problematic (given the detail required during the visit) and supervisors will be informed, [*and*] a spot or shadow visit automatically scheduled.

Caseload reporting

The console has a live report that allows managers access at any time to the current caseload of each CHW. This assists in the planning of staffing needs, as the system is able to send alerts when a CHW's caseload approaches its maximum threshold. The caseload report is able to differentiate between active and inactive cases for each CHW, allowing the report to give an accurate picture of each CHW's workload. When a participating family has temporarily left the area or declines to receive visits for any period of time, their status in the system can be changed from active to inactive. The caseload reports details only of those families who are actively being visited by the CHW. Detailed information about the nature of each caseload is also summarised in the report. It is also possible to view the caseload filtered by any type of risk factor of interest, which is helpful in determining workloads when families or mothers meeting certain criteria qualify for extra intervention visits. The system also provides the data to aid the face-to-face supervision that takes place about particular cases and problem areas.

Future possibilities

In developing the two mobile systems, we have been conceptualising the future possibilities and applications that



MM Responsible	# Late
Mantombi Mdaka	8
Nozipho Ntini	37
Zandile Myeko	22
Funiswa Jali	34
Glenda Madida	30
Vuyiswa Solomon	20
Aviwe Majozi	52
Vuyo Msane	11
Zinzi Mseleku	12
Thembeka Ngola	38
Thato Leseba	9
Doreen Simelane	25
Nonhlanhla Maphalala	17

Date	MM Responsible	# Sessions
30 Jul 10	Aviwe Majozi	4
02 Aug 10	Funiswa Jali	4
10 Aug 10	Funiswa Jali	4
16 Aug 10	Vuyiswa Solomon	5
06 Sep 10	Doreen Simelane	4
13 Sep 10	Thembeka Ngola	4
Today	Glenda Madida	4
27 Sep 10	Aviwe Majozi	4
27 Sep 10	Glenda Madida	7
18 Oct 10	Glenda Madida	4

MM	# Sessions
Nozipho Ntini	1

Source: Mobenzi Researcher n.d., *Philani Mentor Mothers Project*, viewed from http://www.mobenzi.com/researcher/Case-Studies/View/Philani-Mentor-Mothers-Project; Mobenzi Researcher n.d., *Good Start III* (*Saving Newborn Lives*), viewed from http://www.mobenzi.com/researcher/Case-Studies/View/Good-Start-III-(Saving-Newborn-Lives)

FIGURE 5: The visit report.

might further aid information-gathering and management. Whilst we are not as yet utilising these applications, the technology is available to implement the following possibilities:

- We are presently developing a set of screening questions and pictures that can be used by CHWs to screen women for common mental and physical illnesses. Once again, it will take advantage of the ability of mobile technology to send information to a central database and receive specific information back in real time.
- We are in the process of refining the system to ensure that upon SMSing the unique household number, the database sends back a few of the key questions or points to be made for that particular visit, rather than general questions applicable to sessions, as is currently the case. This function will also allow the database to send back more specific individually tailored questions or advice. This will be achieved by developing algorithms that can be reliably applied in the field by persons with limited training. Currently we use the information gathered from the mobile system to fulfill this function during face-to-face supervision, rather than the tailored advice happening automatically via the mobile information system.
- Over time, we will refine this system so that the database sends back more specific individually tailored questions or advice. This will be achieved by developing algorithms that will analyse previously entered basic medical history (previous pregnancies, previous test results, etc.) to generate key messages. For instance, a mother who had a previous history of anaemia will be reminded of the importance taking iron supplements or getting her Hb (haemoglobin) checked again.
- In many countries, most births occur at home and the rapid and timely recognition of early neonatal illness is vital. We are planning (in the Philani study) to use mobile phones with an integrated camera for CHWs to take a photograph of the neonate if they are concerned about an infection or illness. This image can then be transferred in real time and assessed by a trained professional followed by an SMS sent back to the CHW to ensure that the appropriate action is taken or a referral is made.
- We have not been showing videos on the mobile phones, but we realise this feature is easily available to us in the future for two purposes: first, demonstration videos to support CHW message delivery or implementation of more complex intervention activities; and, second videos that CHWs show to mothers and families to supplement their verbal communication and paper-based materials.
- Mobile phones offer the promise of linking data from clinics or hospitals to CHWs. Current studies of loss to follow-up along the 'PMTCT cascade' are not based on linked data, only serial cross sections (Reithinger *et al.* 2007). Yet, as investments are made in health infrastructure, the types of information that need to be linked in integrated systems for health data are similar cross-nationally and regionally, including: tracking individuals or households' health visits over time, and anticipated, developmentally-linked or condition-linked

milestones or check-lists. The functions in such a system are also similar, including: probing, monitoring, training, supporting and educating. These linking activities and functions require the same programed applications across many domains of health applications.

Ethical considerations

The type of data that is available on mobile phones is increasing steadily. Phones also allow data to be collected with a potentially lower respondent burden compared to previously developed platforms. CHWs utilising mobile phones to improve the quality of their work performance can be supported and monitored in ways not previously possible. The potential intrusiveness of this technology for both the CHW and the mother or family being supported and monitored is unlikely to be appreciated by either the CHW or the family. It is critical that we develop standards and strategies for protecting this information with multiple levels of access specified and with the potential opportunities and risks outlined to those from whom the data is being collected. An international set of standards for the protection of privacy and for confidentiality with these types of platforms is urgently needed. In addition, despite the high level of mobile penetration in Africa, many people consider themselves technologically challenged. In our experience with this mobile information system, training some CHWs on the system was easy whilst with others it was more challenging. However, these difficulties were resolved within a two-week period. Central to this was ensuring particularly tight monitoring during the early phase of implementation to ensure that difficulties were picked up and attended to early.

Limitations

Technology will not completely solve the human resource crises confronting healthcare systems globally, nor will it resolve all the complex issues involved in scaling up large scale interventions. It will also not replace the need for the 'human face' of support as well as supervision. There is a danger that this 'human face' might be forgotten given the ubiquity of mobile technology. In addition, many of the reasons for inadequate supervision at scale relate to problems such as poor motivation caused by low salaries, limited professional and career development for supervisors and lack of incentives (Rowe *et al*. 2010). There are problems that cannot be solved by technology or a mobile information and management system. These require another set of human resource skills and interventions as well as a shift in the professionalisation of community health work and supervision. In addition, many countries have policies that support the use of health care institutions rather than CHWs and the system that we have developed would have limited value in these contexts. Qualitative work exploring the interface between the 'human factors' and the new technologies being developed is vital. The field is currently expanding rapidly, and this fast iterative approach should not be lost, but a certain amount of caution is warranted. We need to ensure that time and money are not wasted on ineffective programs in the belief that 'technology' will solve all problems.

Conclusion

This article summarises our experience in two South African RCT's with a mobile information system for supervising a CHW-delivered, home-visit-based community health intervention for pregnant and postnatal women. Mobile phones offer unprecedented opportunities to improve the quality of care provided by CHWs. These devices could be used to dramatically speed up the process and ability of all countries and healthcare systems to meet their healthcare delivery goals. Yet, their potential has yet to be realised. Mobile technology has been widely used by private enterprises, which have made dramatic, rapid, and significant improvements and penetrated entire populations with exceptional speed. Health care, especially health interventions for LAMICs, has not had the technological expertise, the financial commitment, or the political will to implement these strategies broadly. The examples reported in this article represent the first steps in a process of continuous quality improvement, which must begin to keep pace with the possibilities offered by mobile technologies. The web-based mobile information system that we describe in this article has been developed on an open-source platform with no proprietary conditions attached. In addition, the Java's core code is available under open-source distribution terms. It is therefore available to researchers, government health planners or non-governmental and community based organisations to assist in improved management to aid scale up health interventions. The field and general approach is novel and there is a general lack of published literature describing mHealth system experiences with CHWs, particularly in the context of scaling up programs. This article provides evidence that such systems are feasible in aiding to train, sustain, and scale-up CHW programs with a high degree of fidelity and relatively limited in-person supervisory support (i.e. weekly meetings instead of supervisors accompanying CHW teams in the field).

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Competing interest

The authors declare that they have no financial or personal relationship(s) which may have inappropriately influenced them in writing this paper.

Authors' contributions

M.T. (Stellenbosch University), M.R.B. (University of California Los Angeles), I.L.R. (Philani Nutrition and Development Project), T.D. (Medical Research Council), D.J. (University of Western Cape) and M.C. (UNICEF) were the project leaders in both projects. M.T. (Stellenbosch

University), M.R.B. (University of California Los Angeles), I.L.R. (Philani Nutrition and Development Project), J.S. (Stellenbosch University), T.D. (Medical Research Council), D.J. (University of Western Cape), M.C. (UNICEF), P.I. (Medical Research Council), A.F. (Clyral), MColvin (Maromi Health Research) made conceptual contributions to the development of the system. M.T. wrote the first draft of the paper. M.T. (Stellenbosch University), M.R.B. (University of California Los Angeles), I.L.R. (Philani Nutrition and Development Project), D.S. (University of California Los Angeles), A.T. (Massachusetts General Hospital), J.S. (Stellenbosch University), T.D. (Medical Research Council), D.J. (University of Western Cape), M.C. (UNICEF), P.I. (Medical Research Council), A.F. (Clyral), M.C. (Maromi Health Research) contributed to writing the paper and approved the final version of the paper.

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