

Improving the Routine HMIS in Nigeria through Mobile Technology for Community Data Collection

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Abstract. Decision makers in many developing countries lack the required data needed for evidence-based health management. One reason for this is that the routine national health management information systems (HMIS) do not extend to the 'last mile', the communities and the informal setting of villages, where a significant proportion of health events occur. Community-based HMIS data collection is often either poor, or non-existent, in low resource settings. Efforts at establishing community-based HMIS in the past have often failed, or at best, become dysfunctional, beset by challenges with supporting infrastructure such as erratic power supply, poor road transportation and poor telecommunication. However, the advent of mobile technology with its increasing penetration into the rural areas has permitted a re-envisioning and redesign of HMIS data collection. The study described in this paper presents lessons from the application of mobile technology to the collection of data from households and individuals, with the aim of improving the routine HMIS. It utilized a participatory action research approach; and was carried out in Cross River State in Southern Nigeria. The paper makes three major contributions. Firstly, it briefly describes the context and operations of a mobile-based community data collection system designed and implemented to provide high quality health and demographic data for the national HMIS. Secondly, it details organizational mechanisms by which the application of mobile technology reduces the difficulty of data collection from communities and districts, thus strengthening the district-based national health information system. Thirdly, the paper points to emerging challenges and areas for further research. Overall, evidence from the research suggests mechanisms by which mHealth data collection improves the HMIS organization, through savings in organizational resources, increases in information quality and in organizational efficiency (technology as an occasion to restructure) as well as in creating new possibilities for institutionalized HMIS data collection.

Keywords. HMIS, mHealth, mobile technology, community, data collection, developing countries, Nigeria

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1. Introduction

Health management information systems (HMIS) are an essential foundation for evidence-based decision-making within public health systems. However, most HMIS in developing countries² are inadequate in supporting their public health systems as they fail to generate the high quality (timely, complete, accurate and consistent) data needed to support decision-making activities such as health planning [1–3]. Specifically, many HMIS in developing countries do not extend beyond the large health facilities to the ‘last mile’, the communities and the informal setting of villages, where a significant proportion of health-related events occur [4,5]. Consequently, the HMIS data often represents only a tip of the iceberg, missing a substantial amount of important health and demographic events in the communities [6–8]. Efforts at monitoring events within communities in developing countries have often failed, or at best become dysfunctional, beset by poor supporting infrastructure such as erratic power supply, poor road transportation and poor telecommunication as well as a general lack of context-appropriate technology [7]. Consequently, community-based HMIS data collection is often poor, or nonexistent, in such low resource settings. This is the case in Nigeria, the context for this paper, where the Ministry of Health (MoH) has described the HMIS, including its community data collection, as “defective” and unable to generate data for “the simplest indicators” [9].

However, the recent rapid progress in the mobile industry, with the increased mobile penetration in the villages, provides an imperative to re-envision HMIS data collection in a way that addresses some of the data collection challenges at the community level. Already, early pilot demonstrations of mobile technology for health-related activities (mHealth) have successfully demonstrated their potential to increase access to healthcare, improve the ability to diagnose and treat diseases, and expand access to health education and training for health workers [10–13]. Nonetheless, most of these pilot demonstrations are generally small pilots with little impact and “often sit outside of the broader government-led district health information systems”, that is, not within institutionalized settings such as the MoHs and the HMIS [14]. Moreover, mHealth practice and research has been mostly technical and computer science oriented, with too little evidence-generating investigation within the broader institutional public health setting [14]. Accordingly, researchers have emphasized the need to understand the possible mechanisms as well as strategies through which mHealth can improve core public health information systems at the level of the community, and by extension, the larger district-based national HMIS [14–16].

The study described in this paper contributes to bridging these identified gaps. Particularly, it makes three contributions. Firstly, it briefly describes the context and operations of a mobile-based community data collection system designed and implemented to provide high quality health and demographic data for the national HMIS. Secondly, it details organizational mechanisms by which the application of mHealth reduces the difficulty of data collection from communities and districts, thus

² Developing countries in this paper refers to the World Bank’s categorization of low and middle income countries. This is discussed in the World Bank’s article on “How We Classify Countries” <http://data.worldbank.org/about/country-classifications>

strengthening the district-based national health information system as a whole. Thirdly, it points to emerging challenges and areas for further research.

2. Research Context and Methodology

The research was conducted in Akpabuyo, one of Cross River State's 18 local government areas (districts). Cross River state is one of Nigeria's thirty six states, lying in its coastal Delta region where it shares the South Eastern border with Cameroon. With a population of about 2.9 million, it is Nigeria's 27th most populous state but the 19th largest with an area of 21,636 km² [17, 18]. It is mainly an agricultural state with about 75% of its people engaging in subsistence agriculture [19]. Recently it has become Nigeria's major tourist attraction and has a GDP per capita of 3150 USD (above the national average). However, over 70% of the population live on under 1.25 USD a day and the state has among Nigeria's worst indices for poverty, food supply, HIV/AIDS, and maternal and child health; and is considered by the Federal Government as an educationally underdeveloped state [19]. Specifically, the implementation focused on Akpabuyo district, which was selected because it had among the poorest health indices (maternal mortality, etc.) within Cross River State. The research was done within the context of the Nigerian Government's commitment to a comprehensive health sector reform that focuses on developing responsive primary health systems at the grassroots - the district and community levels. It was designed and funded within the framework of the Nigeria Evidence-based Health System Initiative (NEHSI). NEHSI is a collaborative initiative developed in the setting of the ongoing Nigerian health reform, and involving multiple partners – including the Nigerian Government's Ministry of Health at national, state and district levels, the IDRC (International Development Research Centre, Canada), the CIDA (Canadian International Development Agency) and two universities (University of Southern Maine, USA and the University of Calabar, Nigeria) [20].

The NEHSI project aims to support the ongoing health reform in Nigeria through “strengthening local monitoring capacity and fostering a strong, action-oriented evidence base towards the establishment and sustenance of a responsive primary health care system” [20]. A major thrust of NEHSI's approach is the development and implementation of community monitoring systems linked to district health information systems, such that they can support the generation and use of evidence on health service delivery at the community and district levels. This research paper is one of many that describe the community-based data collection activities within the NEHSI project. The authors have been directly involved in the design, development and implementation of a community based HMIS. This direct engagement afforded the authors an in-depth experience of the complexity and intricacies that may be associated with implementing mobile-supported HMIS in a low-resource context.

The authors adopted an implementation research approach founded on participatory action research, where they, as researchers, were directly involved in iteratively designing and implementing organizational change (the information system design and implementation), in collaboration with the stakeholders in the organization [21–23]. Particularly, the authors were guided by the research question: Can mobile technology reduce the complexity of community data collection for state and national

health management information systems? And, if yes, by what specific mechanisms? In addition, what are the associated challenges and implications of mobile data collection, and are there any opportunities for future research?

The participatory research approach involved interactions with key players in the communities in Akpabuyo local government (district), field workers, supervisors and data clerks as well as district, state and federal HMIS officers, health managers (including two successive commissioners of health) at the Cross River State MoH, and colleagues at the University of Calabar. Through these interactions, information received from the participants informed our understanding of their perspectives to the project requirements and informed subsequent modifications of the requirements. Data collected was largely qualitative, obtained through participant observation as well as informal discussions, formal meetings and focus group discussions (please see table 1 below). Essentially, in the first phase of the implementation process (2010 to 2011), we held bi-weekly teleconference (Skype) sessions with the participants. This was useful in facilitating the design and implementation process, and allowed seamless communication among collaborators. In the second phase (2012), fieldwork as well as demonstrations and training sessions with state-level MoH staff on the deployed systems were held, proving very valuable in providing feedback.

Table 1. Overview of qualitative data collection

Qualitative method(s)	Frequency or Number of events	Participants (number in brackets)
Participant observation and informal discussions	Daily for a two year period (mid-2010 to mid-2012)	Data entry staff (6), Community field workers (5), Field supervisors (2), Data analyst (1), District HMIS officers (2), State HMIS officer (1), Health managers at national, state and district level (6), District administration (2)
Formal meetings	16 sessions	District HMIS officers (2), State HMIS officer (1), Health managers at national, state and district level (6), District administration (2)
Group discussions	6 sessions	Data entry staff (5), Community field workers (6), Field supervisors (2)

3. The Implemented Solution and Findings

As earlier discussed, the focus of the project was on exploring mobile data collection, especially how it can improve the quality of data collection in the community-based HMIS. By data quality, we refer to the timeliness, consistency and completeness of data. Consistency in HMIS data means that the data corresponds with the reality on the ground. It requires that data is validated and checked to be correct such that it corresponds to previously collected data and with the current population. For example, data collected for pregnancy should not contain males, or females outside the reproductive age. Timeliness requires that relevant reports are drafted, submitted and transferred on schedule. It entails that forms/reports can be filled/generated easily and quickly and can be sent efficiently and swiftly. Completeness requires that adequate information be entered into the right forms/documents and that sufficient data is

collected for the required analysis. It therefore means that all required data fields are filled appropriately.

We found that, while the paper-based system lacked mechanisms to ensure that these criteria were satisfied (other than manual checks); mobile technology could be adapted to meet these criteria and to ensure more consistent, timely and complete data. With mobile devices, it is possible to automatically validate a significant portion of data for consistency as it is entered into the device; and it is possible to check and enforce that data is complete before it is sent; and after filling, to instantaneously transfer the filled data efficiently (using SMS, Wi-Fi or Mobile Internet).

These requirements were fulfilled by our mobile solution, which we built on the OpenDataKit system (ODK)³. The ODK is an android application designed for data collection and transfer. It allows for the design of forms as well as bi-directional data transfer (downloads and uploads) on the field. In addition, two android applications were developed to supplement the ODK application. These two applications provided two functionalities: a drill-down through the hierarchy from the district level through the household level to the individual level as well as functionality for field supervisors to gain access to the system by logging in and viewing on their mobile devices, data submissions (on the server) sent in by field workers⁴.

The application was provided to the community field workers, for download of designed forms, and submission of filled data to the Opendatakit and OpenHDS⁵ (open-source health and demographic system) server at the state capital. The designed forms captured data on births, deaths, migrations, pregnancies, deliveries, immunization and other pertinent health information on households and individuals.

Consistency of data was ensured by allowing the lookup of previous data points (historical individual data), mainly linked to identification numbers (IDs), which had been generated for each individual. Additionally, consistency checks were built into the forms to disallow the entry of invalid data. The application was easy to fill and data could be submitted via the mobile internet while in the field or via Wi-Fi when field workers were back at the office. To ensure completeness of data, forms without appropriate entries in the necessary fields could not be saved or transferred unless they were filled. Through these mechanisms, the mobile solution ensured collection of data of good quality. In addition, linkage of the data to the state/national data grid was achieved through a functionality we built that allowed data export to the state and national HMIS software [24], the District Health Information System (DHIS2)⁶.

³ <http://opendatakit.org/>

⁴ The project webpage on <http://code.google.com/p/crossriver-openhds/wiki/ConfigureMobileApp> presents numerous screenshots of the mobile application

⁵ <http://openhds.rcg.usm.maine.edu/>

⁶ <http://dhis2.org/>

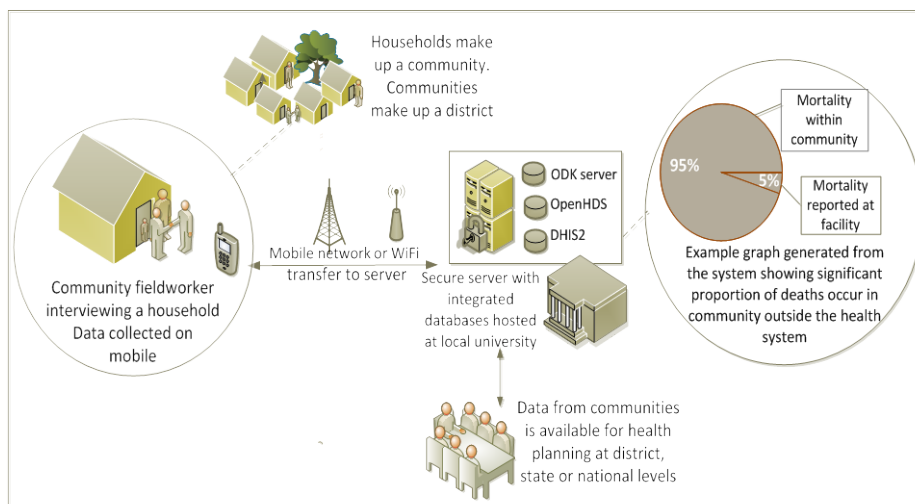


Figure 1. An illustration of the key aspects and concepts of the mobile-supported community data collection for the district-based national HMIS.

Data collection began in early 2011, and by December 2012, the system had registered and followed up on over 5600 people, 1370 households. Among these were over 130 births and 30 deaths that were otherwise mostly missed by the traditional HMIS. In a meeting held with the MoH the data was adjudged as complete and impressive, and the mobile data collection model was adopted for use for data collection across the state. The community field workers and HMIS staff reported that the mobile data collection was easy, friendly and efficient. As one of the fieldworkers commented to a colleague during a discussion session, “The mobile makes our work easier and we do not have carry large reference books. And the great thing is that we can use it when there is no phone network. Just fill in the data and upload it when network signals return.”

Overall, we were able to demonstrate the collection of high quality health data from Akpabuyo and transfer to the state and national HMIS system through the implemented integration with DHIS2. Such a model, if replicated across districts across the country is potentially a game changer for HMIS data collection in the country.

However, migrating from a paper-based to a paperless system was not without challenges. From a change management perspective, it was particularly challenging to transition from a fully paper-based system to a fully mobile-based system. This is partly because processes and practices had to change. For example, in the fully mobile system, the field worker had to learn to use only the mobile device (without carrying paper forms around); and data look up simply used drop-downs instead of the usual stack of paper booklets. The strategy we used was to evolve the system through 3 phases: from the initial paper-based system through a hybrid (combined paper and mobile) phase, and finally to an exclusively mobile system. The (intermediate) hybrid system involved flipping through paper booklets for identification numbers (IDs) for individuals, and other historic information but entering most of the data using the

mobile forms during interviews. Surprisingly, this hybrid system caused more data quality problems than the paper-only and mobile (paperless) system. For example, on analysis of submissions during the hybrid phase, we found that 20% of IDs manually entered failed validation checks.

With the paper-based model, there were fewer errors but these errors could not be resolved quickly because of the need to check up the consistency of data in each paper form – and sometimes this process of quality checks on the IDs could take months to complete. In the paperless (fully mobile) system, these errors were eliminated as IDs were looked up on the fly (in dropdown buttons) at the point of data collection, and of course, submissions were instantaneous, unlike the paper-based system where the submission of filled forms could take days to months. A data manager remarked that: “After switching from the paper-based system to the mobile-based system, we no longer spend months tracing errors in the data capture and entry process. We are able to start analysis immediately after data collection rounds.”

4. Discussion

The scope of the research has been limited by implementation in only one district (Akpabuyo) within the entire State. However, it has been acknowledged as a model for high quality data collection not only by the Cross River State HMIS, but also by the National HMIS. Thus, its contributions are usable and generalizable outside the geographical context in which this work was done. Particularly, lessons learned from our research include mechanisms by which mHealth can reduce the complexity of community data collection for the HMIS.

4.1. Lessons learned from implementation – Mechanisms for mHealth efficacy

Below are important mechanisms for mHealth efficacy that have been identified from the case discussed in this paper where a mobile data collection system largely replaced a paper-based system, improving efficiency and effectiveness in the data collection process. Overall, the mechanisms have been sorted into four aspects:

4.1.1. Savings in organizational resources

Firstly, there were cost savings from the reduced use of paper: The implementation was able to save on the significant costs involved in printing, copying, distributing, transporting and storing of paper forms. (We are exploring approaches in quantifying these cost savings to strengthen the evidence for these cost reductions.)

Secondly, we found that there was a reduction in workforce requirement: less paper-based entry meant a reduction in the number of data entry clerks required and the number of workers involved in the paper supply chain (including printers and driver person-hours). Thirdly, and related to the foregoing, the reduction in the workforce requirement led to more efficient re-organization of the data collection work: data entry workers that were rendered redundant by the mobile data collection were repositioned as data

collectors and data quality supervisors. In this way, mHealth provided an occasion to restructure the organization, streamlining it for more efficiency.

4.1.2. Data quality – Improved Organizational Information Quality for the MoH

The information from the community-level HMIS is an asset to the Ministry of Health, and the quality of the information determines its value and usability. The mobile solution helped in significantly improving the information quality by ensuring consistency, completeness and timeliness of data collection and submission. Moreover, immediate electronic-based capture at the point of data collection (during the interview) in the village eliminated a significant number of errors that are usually attributed to multiple levels/points of data entry and re-entry (such as manually copying out or summarizing data at the district level). In other words, by automating the process starting from the collection in the field, importing, and linking these data with the HMIS (DHIS2), manual transfer errors as well as conceptual misunderstandings and delays in vetting and analyzing data were significantly reduced.

4.1.3. Organizational efficiency

Traditionally, in the paper-based system, there are many steps involved in getting paper forms: from printing the paper forms, to distributing it down to the districts and onto the villages for use. These steps also involve the supervision mechanisms. For example, in the paper-based system, if there were errors, it could need revisits (travel) from the state to the communities. However, with the mobile system, it was more efficient to call the field workers on the field, and to point them to certain mobile forms that needed follow-up. In addition, the agility and speed with which forms are designed and deployed to (i.e. downloaded on the mobile while in) the field improved the efficiency of the data collection workflow. Furthermore, data communication between districts and the state via interoperability and linkage with state and national systems led to improvements in the availability of complete, accurate and timely data for the national HMIS, and was a key efficiency gain. In addition, we were able to leverage the internet to improve accessibility to real-time data hosted on a centralized web-based server. As one of the health managers at the state said, “This project has demonstrated to us that we can rethink how we work in the entire state ministry. We can cut costs, decrease the error rates and be much more efficient in how we collect and transmit data, not just in this district but in the entire state. And I like it that it is web-based, as I can check here in my office and know what is happening across the villages.”

4.1.4. Increased opportunities for the HMIS

The vast majority of HMIS systems enter in aggregate level data because it has been operationally inefficient to collect, store and process vast amounts of individual level data using paper-based systems. However, with electronic data capture at the point of contact, using low-cost mobile solutions, we

found it could be more cost efficient to collect individual level data. Furthermore, because this data collection and storage involves longitudinal individual data, community workers, using the mobile device, can seamlessly retrieve historical data for individuals on follow-up visits. Such seamless retrieval would have otherwise been impossible, or at best difficult, in the paper based system as it would have required checking through piles and shelves of paper for even the simplest data point. In addition, the longitudinal information collected opens up opportunities for targeted sampling and informed (evidence-based) cohort definition for studies (e.g. targeting subpopulations of young children, pregnant women, etc.). This can allow data collection for population-level public health research be more focused, efficient, and allow for statistical inference with confidence intervals. Additionally, we conjecture that further possibilities such as GPS navigation on the phone as well as streamlining follow-up visits for individuals can significantly increase the efficiency of data collection.

4.2. Next Steps and Areas for Further Research

There has been a significant improvement in mobile data collection, and based on the received feedback, the participants have been happy with the progress, though there were a number of challenges faced. We believe these challenges, nevertheless, are surmountable, mostly by specific workarounds and emerging solutions, and, are the focus of ongoing and future work, and represent areas of recommendations for further efforts by mHealth researchers. The challenges have been categorized into technical and organizational.

4.2.1. Technical Challenges

Data can readily be lost if the mobile device is lost (or stolen) before the data is successfully transferred. And poor network coverage can delay data transfer. However, mobile penetration continues to improve, thus increasing possibilities with synchronizing collected data more often (with the server) from within different locations in villages. Another issue is that of mobile device downtime due to irregular power supply, which occasionally hinders data collection. However, there are emerging approaches to powering mobile devices extraneous to the power grid, e.g. portable solar systems and portable recharging devices. In addition, the newer models of tablet devices, which run for longer than most mobile phones, provide a viable and cost-efficient option – and they can equally be powered without reliance on the traditional power grid.

During our research, we found that there was the need for an information system to assist field managers and HMIS staff in fieldwork management. This could be in the form of a dashboard that allows for managing field operations e.g. dashboards for monitoring form submissions. There could also be an automated messaging system that tracks and forwards important instructions back and forth field workers involved in the data collection.

4.3. Organizational Challenges

Subtle resistance to change was encountered as the mobile system introduced some redundancies in the function of the data entry staff. The work of data entry staff had to be reorganized i.e. some intermediary roles were removed and workers relocated to the field as data collectors and supervisors.

In addition, as has been previously reported [25], there was a policy gap in HMIS implementation – there was insufficient guidance from the existing HMIS policy on pertinent aspects of data collection e.g. data security & privacy. However, there is emerging work in this area – the mHealth alliance, working with law firms in Nigeria and with the MoH are working towards developing a context-sensitive policy document around this. Insufficient understanding and weak local organizational capacity at the MoH was a challenge. In the course of the work, we have carried out training sessions and made recommendations for more capacity building at the MoH. We believe this should be a major focus for future work.

Beyond meeting these challenges, next steps would involve continuing field testing of the mobile application on tablets, and improving usability design. In addition, we hope to explore scaling, build synergies and examine more possibilities that mobile technology can offer. Concerning synergies, there are other mHealth projects in Nigeria using mobile technology to improve HMIS data collection. For instance, some authors [12, 25] have described the use of SMS to improve HMIS data transfers by community health workers from health facilities in Nigeria. It would be interesting to explore synergies with similar mHealth projects to allow for even more integration and scalability.

5. Conclusion

This paper has pointed to challenges with the community-based HMIS-related data collection and described a successful mobile technology-based approach to meeting them. Particularly, it highlighted the mechanisms and strategies through which mobile technology can facilitate improvements in HMIS data collection. Overall, evidence from the research suggests that mHealth efficacy translates to savings in organizational resources; increases in information quality and organizational efficiency; and the opening up new possibilities for HMIS data collection. While the gains also come with challenges, these challenges seem to be surmountable and are important areas for future research.

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