

Original Contribution

Open Access

Characterizing the Flow of Health Information in Rural Uganda: Is there a Role for Mobile Phones?

Laura E. Jacobson¹, Francis Bajunirwe², Bryan J. Vonasek¹, Leonidas Twesigye², James H. Conway¹, Monica J. Grant³, Ajay K. Sethi^{1,4}

¹University of Wisconsin-Madison, School of Medicine and Public Health, USA

²Department of Community Health, Mbarara University of Science and Technology, Uganda

³Department of Sociology, University of Wisconsin-Madison, USA

⁴Department of Population Health Sciences, University of Wisconsin-Madison, USA

Correspondence to: Laura E Jacobson, University of Wisconsin School of Medicine and Public Health, 750 Highland Ave. Madison, WI 53726, USA. Email: jacobsonlaura@gmail.com

ARTICLE INFO

Article history:

Received: 29 Oct 2014
Accepted: 14 Mar 2015
Published: 1 Jul 2015

Keywords:

- Health system
- mHealth
- Health policy
- Health communication
- Uganda
- Resource limited settings

ABSTRACT

Background: The United Nations' post-2015 development agenda stresses a need for a "data revolution." In Uganda, capturing recent health data can be challenging. Capitalizing on the expansion of mobile phone access in developing countries, public health providers could use mobile phones in the health system as tools to aid data collection and improve health information reporting. To understand if mobile phones can play a role in connecting policymakers with health information, we sought to characterize the flow of health information between health workers and policymakers in rural Uganda and to evaluate if mobile phone technology can support the work of frontline workers.

Methods: From May to July 2013, semi-structured interviews (n=20) were conducted with 9 health workers and 11 policymakers in two rural districts of Southwest Uganda. Qualitative thematic analysis of the transcripts identified the directionality and types of information transmitted; the perceived utility of mobile phones; and health system vulnerabilities.

Results: Health information moved primarily in one direction: from health workers to policymakers. Health workers frequently discussed the use of anecdotal reports when making decisions. In contrast, policymakers referred to health information that was summarized, analyzed and compiled. While both groups had a positive perception of mobile phone utility in the health system, noted concerns included scalability and sustainability, in particular with respect to cost and maintenance. Human resource shortages were identified as one of the biggest barriers to adopting new technology and/or improving the health information system.

Conclusions: Creating bi-directional channels of communication between health workers and policymakers in Uganda would improve communication and could help strengthen the health information system. Increasing health workers' access to data summaries may reduce the reliance on anecdotal reports and improve decision-making. Despite a positive outlook on mobile phone utility, noted concerns should be considered and addressed before routinely integrating the mobile phones into the health system.

Citation: Jacobson LE, Bajunirwe F, Vonasek BJ, Twesigye L, Conway JH, Grant MJ, Sethi AK. Characterizing the Flow of Health Information in Rural Uganda: Is there a Role for Mobile Phones? J Public Health Dev Ctries. 2015; 1(1): 4-13.



INTRODUCTION

The United Nations' post-2015 development agenda stresses a need for a "data revolution." This includes improving the quality of statistics and information available; actively taking advantage of technology; using crowd sourcing strategies to capture health information; and improving the connectivity between individuals and information [1,2]. Connecting decision makers with reliable recent health information would strengthen decision making, guide priorities, and increase accountability of leaders worldwide. The World Health Organization (WHO) describes a health information system (HIS) as one of the six essential building blocks of a health system. A well-functioning HIS includes the production, analysis, dissemination, and use of accurate and timely information on determinants of health, health systems performance metrics, and the health status of the population [3].

Evaluations of routine health facility data in resource-limited settings have identified consistent HIS problems that include lack of completeness, accuracy, and timeliness [4]. Reliable public health information can assist policymakers, health workers, and development partners to track health system level performance and support development of health policies that align with the needs of a population. The purpose of this qualitative study is to characterize the flow of health information between health workers and policymakers in rural Uganda; to identify areas within the health system where the frontline workers perceive vulnerabilities; and to evaluate if mobile phone technology (mHealth) can play a role in supporting the work of health workers and policymakers in a rural Ugandan setting.

Uganda

In the sub-Saharan African nation of Uganda [population 37.58M, 85% rural] [5], capturing and disseminating recent health data - particularly in rural areas - can be an arduous task. Two decades of wars beginning in the 1970s resulted in a decline in population health indices and a damaged health system infrastructure [6]. Post-conflict reconstruction has focused on re-

establishing a political and economic environment conducive to growth. During this period of rebuilding, increased funding has been dedicated to support the health sector. While reports from the Ministry of Health (MoH) indicate that the health and well-being of Ugandans has improved since the 1990s, better data on health outcomes is needed to thoroughly evaluate progress [6].

Until the 1990s, Uganda had a centralized paper-based HIS that focused only on morbidity and mortality reporting. Since then, the MoH created a health management information system (HMIS) that emphasized the use of local health information [6]. This change was part of an overall system reform where more responsibility was formally transferred to local levels of the health system. The MoH expected districts to develop their own health plans to reflect the national policy. However, this shift towards decentralization forced already overburdened health workers to collect, process, and report routine data relevant to national policy [6]. Between 2000-2010, the HMIS relied primarily on paper-based forms used at the local levels that were dispatched to the district offices and were then submitted to the MoH by email, fax, phone or physical delivery [7]. Despite this investment in infrastructure, a 2010-2011 evaluation of health facility data quality by the Ugandan MoH and WHO revealed problems with the consistency, timeliness, accuracy, and completeness of health information [8]. In July of 2012, the District Health Management Information Software System version 2 (DHIS2) was adopted nationally to facilitate the reporting of health data [7]. Although evaluations of DHIS2 demonstrated improvements in the timeliness and completeness of data reported from the districts to the national level, local and community-based health centers continued to use paper-based procedures as of March 2014 [7].

mHealth

Recognizing a need to improve the collection and dissemination of health information for health workers who are still relying on paper-based strategies, researchers, development agencies, and public health organizations in

recent years have designed projects and interventions that use mHealth to support health services, education, and informatics. Although the potential for mobile phones to simplify the collection of population surveillance data is great, there is little published work that evaluates the practicality of this application.

Estimates of maternal mortality rates in sub-Saharan Africa remain high, with around 500 maternal deaths per 100,000 births; however, the data used to produce these estimates are periodic and incomplete [9]. In response to the 2012 UN Commission on the Status of Women's goal of eliminating maternal death worldwide, Gilmore and Gebreyesus, of the MoH in Ethiopia, called for an "infectious disease surveillance approach" using the Internet and mobile phones to report every single maternal death in order to produce better data required for evaluation and monitoring of this goal [10]. Complete and real-time surveillance data could provide feedback to policymakers that would offer a strong basis for action.

Due to their ubiquity and increasing popularity, mobile phones have the potential to strengthen the HIS by aiding the health work force and connecting health system actors with critical information. Proponents of mHealth cite continued growth of mobile phone network coverage in developing countries and the ability to reach many connected individuals as fundamental components of the potential success of this field [11,12]. However, mHealth has emerged as a patchwork of "apps" that serve a narrow focus and could benefit from coordinated integration into existing health systems [13]. There is widespread interest in mHealth development in Uganda, but these programs have not been coordinated with national changes to the HIS. In response to this need for harmonization, in 2012 the MoH called for a halting of all mHealth projects in Uganda until they receive MoH approval [14]. Coordination on a policy level could result in strategic approaches that strive to avoid exacerbating current health disparities and create projects that are sustainable. Given the need to move away from vertical mHealth initiatives into cross-sectorial systematic strategies, leaders in the mHealth field have recently released a framework that strives to capture the complexities and interdependencies

of the health system in order to identify mHealth research priorities and investment needs [15]. Thoughtful development of evidence-based mHealth tools and political support to integrate this technology into a health system is critical to the success of mHealth.

System-level strengthening, such as improving health information strategies and developing new technology, requires coordination between policymakers, district administrators, and health workers. To understand if mobile phones can play a role in supporting the work of health workers and policymakers by connecting them with timely health information, this research study was designed to characterize the flow of information between health workers and policymakers in two South western Ugandan districts and identify areas within the health system where frontline workers perceive a need for improvement.

MATERIALS AND METHODS

Site Selection and Recruitment

Data collection took place from May to July, 2013 in two rural districts in Southwest Uganda (populations 215,000 and 460,000). These districts were chosen due to their proximity to Mbarara University of Sciences and Technology, the coordinating University and site of the overseeing institutional review board. These districts are intentionally not named to retain confidentiality of the study participants who hold elected offices. Ethics approvals were obtained from both Mbarara University of Science and Technology and the University of Wisconsin Health Sciences Institutional Review Boards. Written informed consent was obtained from all research participants and interviews were conducted confidentially.

Eligible participants were health workers or policymakers living and working in the selected districts, able to converse and read English, and willing to consent to a confidential interview. We used purposive, maximum variation sampling to gather the widest range of experiences and opinions, seeking diversity across a range of characteristics including professional position, years of professional experience, and gender. Community liaisons from both districts worked

with the study team to make introductions to the local leaders and to sustain communication between the research team and the potential participant groups. A sample size of 20 participants was chosen as a feasible number to allow for deep, case-oriented analysis in the available timeframe of this pilot qualitative study [16]. Health worker and policymaker participants were recruited primarily through phone contact, personal introductions made by community liaisons, or in person recruitment at regular staff meetings. A total of 29 potential participants were approached and 20 individuals enrolled in the study. Reasons for not participating included lack of interest, lack of time, and other administrative responsibilities. For this study, policymakers were defined as district health officers (DHO), district level administrators, local councilors (LC), and Members of Parliament (MP). Health workers were defined as nurse midwives, doctors, and health facility directors.

Interview Procedures

The first author conducted semi-structured, in-depth interviews with enrolled participants at the place of the interviewee's employment. Interviews were chosen as the primary source due to the exploratory nature of this research. Relevant health system strengthening and organizational behavior literature informed the interview guide [17, 18]. Each interview lasted approximately 45-60 minutes.

General questions were asked about the participants' workflow and documentation practices, their perceptions of technology in the health system, perceived barriers to improving the health system, and their roles in the community. Participants were asked to describe characteristics of their district that make life good for those who live there. They were then prompted to discuss the challenges they encounter in their districts that they find relevant to their work. Participants were asked to describe the sources of health information that they have access to when making professional decisions as well as their own procedures for producing and reporting health data. Follow-up probes included questions around the format and frequency with which they receive and report health-related data. Finally, they were asked if they had heard of, seen examples of, or participated in mHealth initiatives or studies. Participants then shared their opinions on the

use of mobile phones in a rural healthcare setting and were asked to elaborate on perceived or experienced benefits and/or concerns.

Analysis

Our approach used techniques from thematic analysis, which allow for developing codes based deductively on initial interview questions and inductively on emergent themes [19]. Audio-recorded transcripts were transcribed by the first author and NVivo 10.0 software was used to organize and analyze these data [20]. The entire text of the interview was entered into a database and text blocks were sorted into broad themes that included: 1) health data and reports; 2) mobile phone or mHealth mentions; 3) health system-level issues. These data were coded to answer questions about the flow and type of health information transmission; awareness and attitudes of mHealth use; and themes of health system vulnerabilities. Coding was performed by the first author and reviewed and cross-checked by the third author. The analysis plan and preliminary findings were presented to stakeholders at the Ugandan site locations in November 2013.

RESULTS

The final sample included 11 policymakers (4 LCs, 2 DHOs, 4 administrators, 1 MP) and 9 health workers (3 doctors, 3 nurse midwives and 3 health facility directors). This sample included a total of 13 men and 7 women (5 of 9 health workers and 2 of 11 policymakers were women). Participants had a median of 3 years of professional experience (range 1-21 years).

Direction and Type of Health Information

Interviews with health workers and policymakers revealed that the types of health information generated by respondents included anecdotal reports, detailed statistics, compiled and analyzed summaries, and digital information such as web based or mobile phone displayed reports. However, health workers discussed the use of anecdotal reports with greater frequency than policymakers. All health workers interviewed (100%) used routinely available anecdotal reports to make decisions. When

asked to describe the health information that informed their work, one health worker stated:

“We rely on referral notes and they detail exactly what is happening with each patient. The time she arrives, what would be the delay and why. So when a client comes, we capture if she was referred, if she came on her own, and where was she referred from.”
–Health worker B2

When prompted to discuss access to larger population-based health data, this health worker replied:

“For the district-level, you can get that at the district office but I don’t have that here.”
–Health worker B2

Responding to the same question, if they have access to district-level health data in the clinical setting, another health worker responded:

“No, I don’t. I know the patients we admit and at the end of the month, we are able to know how many we have admitted, how many have died and that’s where we stop on the ward.” –Health worker A3

Policymakers, however, infrequently mentioned use of anecdotal reports. Instead, one of the policymakers referred to using health information that was summarized, analyzed and compiled.

“We summarize [health data] monthly and also send annual reports to the ministry. It is very helpful to look at past trends for what we have seen in the past year and I will say that is the priority area. We get this from reports from staff [health workers] on what is happening each day and week.”
–Policymaker A7

When evaluating the direction of health information flow, results showed that health information generally travels in one direction: from health workers at health centers and hospitals to administrators and policymakers at the district level. Seven of nine (78%) health workers interviewed stated that they send health reports to the district. No health workers reported receiving routine reports from the district-level policymakers.

“These data we transmit it to the district to help them know how this burden is actually

affecting their district. We are also required to send this data every quarter to the ministries in Kampala. To give the country its general picture of health data. So once we’ve done that we also get feedback from the ministry.” –Health worker A3

This health worker mentioned receiving annual national health reports from the MoH that reported on aggregate country-wide data but no specific local health data was reported as received by any of the health workers. Conversely, all eleven policymakers reported receiving reports from health workers and none mentioned reporting back the compiled information.

Awareness and Attitudes towards Mobile Phone Use for Health Information Dissemination

Both health worker and policymaker participants were generally aware of mHealth where a total of 14 (6 health workers and 8 policymakers) of the 20 interviewed had heard of or had participated in an mHealth initiative in some capacity. While individuals held either positive or neutral attitudes towards mobile phone use for health information when asked directly, further exploration into respondents’ narratives provided deeper insight into the perceived benefits and concerns regarding mobile phone use in the healthcare sector. Since questions were general and open-ended, responses included opinions and perceptions on any type of mHealth project, including the use of mobile phones to support a health work force, collect surveillance data, or for community health needs. Themes of positive perceptions included their broad reach, high mobile phone ownership, and receiving recent information.

“I think [mHealth] is the way to go because many interventions are using the mobile platform now: you can do money transfers, you can easily get information from people. And since many people have them, it is the way to go.” –Policymaker A9

“It is a very good strategy because almost everybody has a phone.” –Health worker B2

These themes were common among individuals (both health workers and policymakers) who had a positive opinion of mobile phone use in

healthcare. However, some policymakers voiced concerns with the process of integrating mobile phones into the current system:

“We hear of [mHealth]; only that we are not able to implement. Of course [mobile phones] would work for quick transmission of information, it would really help. Only that we have not gotten that far. We have no internet at the district thus far.”
–Policymaker A3

“I can see potential coming up to use [mobile phones] in the communities as every village employs someone who know a bit about health. I see the mobile phones could be used to revolutionize the health service delivery. If someone has obstructed labor in the village you can ring to the [Village Health Team (VHT)], but we have not organized it, we have not taken advantage of these advances.”
–Policymaker A1

In addition to these concerns, both policymakers and health workers shared concerns about the cost and sustainability of mHealth.

“But the challenge is to pay for [mHealth]; that you might not have airtime on [your phone]; you might rely on other people calling you.” –Policymaker A5

The above policymaker identified airtime or phone credit as a private cost versus part of the potential program cost, inferring that they did not think of the phone as part of the health system in an mHealth program or intervention. This policymaker was possibly also concerned about individuals spending airtime for personal use. One health worker who was concerned about the sustainability of mHealth shared this theme of personal use:

“For the few times we have experimented [with mobile phones] they have been found very useful but there are issues with sustainability. The barriers to this problem are financing that technology. And phones are things that can easily get lost, can easily get stolen, they can fall and break, and for how long are we going to repair and replace.” –Health worker B6

This health worker went on to draw a connection between mobile phones and a past experience

when they were involved in an intervention that supplied the VHTs with bicycles to aid their practice.

“The VHT would use the bicycles to supplement their other activities aside from doing the actual activity for which the bicycle was given. But you find that in less than one month, the tires are gone, they are needing repair, the spokes are gone. And these are for bicycles that are much easier to maintain than phones.” -Health worker B6

Unlike policymakers, the health worker group voiced concerns about the operability of the devices. These issues included the need for extensive training for all end users; difficulty entering information; burdensome data entry requirements; and the literacy of users in the community setting.

“For health projects we need to be more specific about the information that you want to collect by mobile phone. If the information is a lot, and the demands are a lot on them, if it is too big, they will not use it.” –Health worker B7

Health System Vulnerabilities

General health system vulnerabilities identified by participants may present barriers to HIS improvement and successful mHealth integration. When responding to questions about their job, their roles in the community, and community health, themes that emerged included health worker shortages, an overcrowded health system, and delays in providing care. These are widely recognized characteristics of healthcare organizational effectiveness [17]. When asked the question “What makes life good for the people who live in your district?” only policymakers mentioned good health and access to health services as a response. No health workers commented on the access to services as a positive aspect of living in their district.

“We have health centers in all the sub counties and there is also [a] health center at [the] parish level. So the services are close to the people.” –Policymaker A4

On the contrary, only health workers mentioned delays in care and lack of access to health services as a problem in their district.

“Because sometimes the patients come in when they are terminally ill, when there are some issues that could have been reversed or prevented, but they come when it is too late and you can rarely do much.” –Health worker B4

Results also revealed much agreement between health workers and policymakers on the topic of human resource shortages. The majority of policymakers (7 of 11, 64%) and health workers (6 of 9, 67%) mentioned health worker shortages as one of the biggest barriers to improving the health information system as well as the health of the people in their district.

“At health center [level] 3s, we have clinical officers and we meet with the in charges and doctors although we don’t have enough staff, they say we don’t have enough money to pay them so we are making do with only little staff which is not enough.” –Policymaker A5

“The staff is not enough, so sometimes you find yourself working for long time and you are exhausted. We could work our best if we had more people.” –Health worker B9

“We don’t have an adequate information system. We need a comprehensive hub to capture the information. Some people are doing some work but they are not capturing it efficiently. Then of course you have the cost, the human resources to do this are not there.” –Policymaker A4

DISCUSSION

These qualitative findings presented in this study show that while there may be a role for mobile phones in healthcare, there is also a perceived need to strengthen the health system in Uganda distinct from the introduction of new technology. This study highlights the unidirectional nature of information flow and the disparities in access to summarized health information between health workers and policymakers. To promote more informed decision making in the healthcare setting, policymakers should ensure that health

workers on all levels have more access to the same summarized and compiled reports that they use for decision making. In addition, this study contrasts how health workers and policymakers view the health system in this developing country. While health workers focused on its deficits and limitations, policymakers viewed the local health system as an asset to the community. To reduce this type of discrepancy, creating bidirectional channels of communication may help foster a shared vision for system-wide improvement as well as improve access to relevant, analyzed health information needed for decision making and system strengthening. Additionally, consistent concerns about health worker shortages from both health workers and policymakers suggest that perhaps the need to recruit and retain a larger workforce is a greater priority than the need for mHealth development. These findings complement studies in Uganda that showed the health worker shortages significantly impacted quality of life and job satisfaction for health workers and that these shortages have complex, multifactorial causes [21,22].

The results of this qualitative study challenge the idea that high mobile phone ownership and established networks, which are already in place in resource-limited settings, create the necessary environment for mHealth initiatives to succeed. Like bicycles, mobile phones do get lost, broken, or stolen and if they are required for employment, there is an expectation from the workers that this equipment is supplied and maintained by the employer. Respondents in this study indicated that workers and community members participating in mHealth interventions often see device ownership as an incentive to adopting this technology or as a job entitlement. If researchers and health employers anticipate utilizing existing devices while users expect new phones to be supplied, this disconnect could potentially have budgetary implications or cause conflict. This research may help promote and inform future mHealth initiatives in developing countries by providing evidence that clarifying expectations around ownership and maintenance of mobile devices used in the healthcare setting is critical to the success of mHealth work.

This work complements growing interest in health system strengthening and adds a mobile phone component to the discussion. To date,

most of the literature on health system strengthening shows a need for consolidating services and taking advantage of economies of scale [23]. Due to the complex and context-specific nature of health system strengthening, it is difficult to develop a unified solution and the evolution of healthcare delivery cannot be centered on a single strategy. Existing health promotion models using volunteer health workers in Southwest Uganda have demonstrated positive health outcomes [24]. Integrating these non-technical models with advances to the HIS and mHealth strategies could lead to greater stakeholder interest in technical solutions if the end-users, such as the health workers and policymakers, are involved in the development of the tools they will use. Understanding the current practices, perceived vulnerabilities, and attitudes of frontline workers is critical to the success of health system strengthening. It is possible that certain types of health information such as laboratory values or drugs stocks may be more amenable to mobile phones than others (e.g., medical histories). More research is needed to identify the best way to capitalize on mobile phone technology in the health system.

Despite a positive outlook on mobile phone utility, concerns such as cost, sustainability, and operability should be evaluated and mitigated before integrating them into the health system. Researchers, leaders, private sector, and nongovernmental entities involved in technology innovation must cooperate to define common goals and create an mHealth landscape that steers projects towards evidence-based interventions and sustainable user-tested models. There is great potential for the public health community to use mHealth tools to support a health work force, to connect individuals with timely information, and to promote community health education when initiatives are designed to meet local needs, are synchronized with existing health system practices, and are implemented by those who will use them.

This study has several limitations that may influence the results. While interviewees were representative of typical roles in the health and political system of Uganda, the study sample is small and recruitment was limited to just two districts. These findings may not be applicable in urban settings or in other developing nations

who have unique health system challenges. Furthermore, interviews were conducted by a visitor [first author] and were limited to English speakers. Due to the exploratory nature of this research, further evaluation may be necessary to confirm and expand on these findings.

CONCLUSIONS

Stronger health information systems are needed in Uganda to aid local workers and to meet national and global health development goals. Accurate, complete, and timely health information can equip policymakers with information necessary for thorough monitoring and evaluation of health systems performance, and the health status of a population. Harmonized health and development goals between health workers and policymakers are important for strengthening health systems. Creating bi-directional channels of communication between health workers and policymakers in Uganda would improve communication and could help strengthen the health information system. Increasing health workers' access to data summaries may reduce the reliance on anecdotal reports and improve decision-making. Further, improving health communication between health workers and policymakers and supplying both groups with accurate, timely, compiled, and analyzed summaries can highlight the scope of emerging epidemics, improve monitoring of community health, and reinforce the social and economic benefits of improving the overall health system. Reporting routine, reliable national health information to global agencies such as WHO or the World Bank may accelerate the urgency for further investment to make health system strengthening in Uganda a global priority.

AUTHORS' CONTRIBUTIONS

LEJ made substantial contributions to the design of the work, the collection, analysis, and interpretation of the data, and drafting the manuscript. AKS and FB made substantial contributions to the design of the work, the analysis and interpretation of the data, and the supervision of the first and third authors. BJV and LT made substantial contributions to the

collection of the data. JHC and MJG made substantial contributions to the analysis and interpretation of the data. All authors reviewed, revised, and approved the final version of this manuscript and agreed to be accountable for all aspects of the work and research conduct.

ACKNOWLEDGEMENTS

The authors would like to thank the leaders and staff at Mbarara University of Science and Technology for hosting the researchers; the study participants; Lori DiPrete Brown, MSPH, MTS of the University of Wisconsin-Madison Global Health Institute for methodology assistance; and the University of Wisconsin Master of Public Health program staff for administrative support.

FINANCIAL SUPPORT

This research was supported by a grant from the University of Wisconsin-Madison Global Health Institute.

CONFLICT OF INTEREST

Authors have declared that no competing interests exist.

REFERENCES

1. United Nations. A New Global Partnership: Eradicate Poverty and Transform Economies through Sustainable Development. *The Report of the High-Level Panel of Eminent Persons on the Post-2015 Development Agenda*; 2013.
2. Center for Global Development and African Population and Health Research Center. *Delivering on the Data Revolution in sub-Saharan Africa: Final Report of the Data for African Development Working Group*. Washington, DC: Center for Global Development; 2014.
3. World Health Organization. *Strengthening Health Systems to Improve Health Outcomes: WHO's Framework for Action 2007*.
4. Mates KS, Bennett B, Mphatswe W, Barker P, Rollins N. Challenges for routine health system data management in a large public programme to prevent mother-to-child HIV transmission in South Africa. *PLoS One* 2009; 4: e5483.
5. The World Bank Website (Accessed 8 October 2014, at <http://data.worldbank.org/country/uganda>).
6. Gladwin J, Dixon RA, Wilson TD. Implementing a new health management information system in Uganda. *Health Policy and Planning*. 2003; 18: 214–24.
7. Kiberu VM, Matovu JKB, Makumbi F, Kyozira C, Mukooyo E, Wanyenze RK. Strengthening district-based health reporting through the district health management information software system: the Ugandan experience. *BMC Medical Informatics and Decision Making*. 2014; 14: 40.
8. Ministry of Health Uganda Assessment of health facility data quality: *Data quality report card Uganda, 2010–2011*.
9. World Health Organization Website: Maternal Mortality Fact Sheet May 2012 (Accessed 12 July 2014, at <http://www.who.int/mediacentre/factsheets/fs348/en/>).
10. Gilmore K, Gebreyesus TA. What will it take to eliminate preventable maternal deaths? *The Lancet*. 2012; 380: 87-8.
11. World Health Organization: mHealth New Horizons for health through mobile technologies; 2011.
12. Aranda-Jan CB, Mohutsiwa-Dibe N, Loukanova S. Systemic review on what works, what does not work and why of implementation of mobile health (mHealth) projects in Africa. *BMC Public Health*. 2014; 14: 188.
13. Estrin D, Sim I. Open mHealth Architecture: An Engine for Healthcare Innovation. *Science*. 2010; 330: 759-60.
14. A Ugandan mHealth Moratorium is a Good Thing (Accessed 17 September 2014, at <http://www.ictworks.org/news/2012/02/22/ugandan-mhealth-moratorium-good-thing>).
15. Mehl G, Labrique A. Prioritizing integrated mHealth strategies for universal health coverage. *Science*. 2014; 345: 1284-87.
16. Sandelowski M. Focus on Qualitative Methods: Sampling in Qualitative Research. *Research in Nursing & Health*. 1995; 18: 179-83.
17. Beehr TA, Newman JE. Job Stress, Employee Health and Organizational Effectiveness: A Facet Analysis, Model, and Literature Review. *Personnel Psychology*. 1978; 31: 665-99.
18. Frenk J. The Global Health System: Strengthening National Health Systems as the Next Step for Global Progress. *PLoS Med*. 2010; 7.

19. Daly J, Kellehear A, Gliksman M. *The Public Health Researcher: A Methodological Approach*. 1997 Oxford University Press.
20. NVivo qualitative data analysis software; QSR International Pty Ltd. Version 10, 2012.
21. Opollo JG, Gray J, Spies LA. Work-related quality of life of Ugandan healthcare workers. *IntNurs Rev*. 2014;61: 116–23.
22. Kasper J, Bajunirwe F. Brain drain in sub-Saharan Africa: contributing factors, potential remedies and the role of academic medical centers. *Arch Dis Child*, 2012; 97: 973-79.
23. Kim JY, Farmer P, Porter ME. Redefining global health-care delivery. *The Lancet*. 2013; 382: 1060-9.
24. Brenner JL, Kabakyenga J, Kyomuhangi T. Can volunteer community health workers decrease child morbidity and mortality in Southwestern Uganda? An impact evaluation. *PLoS ONE*. 2011; 6: e27997.