

Theme: Building health information systems

Innovations in monitoring vital events

Mobile phone SMS support to improve coverage of birth and death registration: A scalable solution

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School of Population Health
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Acronyms and abbreviations

CR	civil registration
CRVS	civil registration and vital statistics
HDSS	health and demographic surveillance system
IHI	Ifakara Health Institute
mCRVS	use of mobile communication devices for CRVS
mHealth	mobile health
MOVE-IT	monitoring of vital events through use of information technology
RITA	Registration, Insolvency and Trusteeship Agency
SAVVY	sample vital registration with verbal autopsy
SMS	short messaging service
Swiss TPH	Swiss Tropical and Public Health Institute

Summary

Civil Registration (CR) of births and deaths is an essential component of any health information system. Globally, across low income countries, CR suffers from unacceptably poor quality coverage. This Health Information Systems Knowledge Hub (HIS Hub) working paper summarises and reports the results, conclusions and outlook from a small six-month project that investigated the potential of introducing a mobile phone step into the routine CR system in a rural district in Tanzania. The project developed a computer application that could receive SMS messages—from existing basic mobile phones of community-based CR officers—and feed them directly to the District Registrar’s office and computer. The message contained the details from the birth or death notification form. The system provided instant access to notifications and automatic feedback to the Village Executive Officer (VEO) if the family that experienced the birth or death event failed to register the event for certification. It also prompted the VEO to follow up with the family by conducting a questionnaire, administered by mobile phone, to determine and communicate the reasons for the non-registration. The District Civil Registrar was also able to monitor trends in these notifications via a user-friendly web-based browser and dashboard. The system was tested for six months and validated against an independent prospective household surveillance system that monitors pregnancies, births and deaths in the same period.

In summary, the findings showed that the routine CR system notified only 28% of total births in the period. Adding the SMS step increased this to 51% of births.

The routine CR system notified only 2.1% of deaths in the period. Adding the SMS step increased this to 14% of deaths. The SMS step therefore made significant improvements in the notification step (and modest improvements in the registration step) of routine CR. However, both notifications and registrations still fell well short of reality at community level.

The most important finding of this pilot is that the current CR system in at least the study district, and likely in most of rural Tanzania, is essentially unable to provide adequate registration coverage for births and deaths, and that coverage is so low that even log order improvements are insufficient to lift it to satisfactory levels (in excess of 90%). This, as yet, says nothing regarding the quality of the data. No overwhelming reason is provided by families for the low reporting rate, suggesting that the problems are highly systemic and will need a radical redesign of CR processes to solve. To the extent that similar problems prevail in other low-income countries, it is clear that whatever these processes will be, some form of scalable real-time mobile communication such as SMS will greatly facilitate coverage levels. This pilot shows that such technology is feasible. But these results also emphasise the need for an end-to-end overhaul of the architecture and processes of how CR systems are built and integrated into the information fabric of a country. Small incremental technical fixes will not suffice.

Introduction

Civil registration (CR) systems serve three main uses: 1) they are the source of legal documents that provide evidence used to protect human and civil rights; 2) they provide data that constitute the vital statistics for a country which are necessary for planning, implementing and evaluating development programs across sectors; and 3) they are the prime source of longitudinal demographic and health data for a country to monitor progress towards key national and global goals. CR systems are, however, often weak or incomplete in developing countries. Many countries do not have records of vital events for their population, so they lack the data needed to guide national planning in various sectors, particularly health. Vital statistics that include cause of death are the cornerstone of a country's health information system. Vital statistics on cause of death can be added to CR systems and are used to inform health policy and health planning, monitor health programs, and prioritise health research activities. This combination allows CR with vital statistics (CRVS) to become a complete system of information.

In most low-income countries, the underlying CR system for simple counting and certifying of birth and death events is a largely manual process whereby people capture data on paper and then enter information into a computer. The process is slow and cumbersome; it allows information to be seen by only one person in one place at any one time, and does not deliver any management information until the details from the various forms have been entered into the system.

The Swiss Tropical and Public Health Institute (Swiss TPH) and the Ifakara Health Institute (IHI), with a grant from the University of Queensland's Health Information Systems Knowledge Hub, piloted a six-month intervention on mobile phone SMS support to test the concept of improving coverage of birth and death registration in Tanzania. The pilot, called 'Monitoring of vital events through use of information technology', or MOVE-IT, was conducted in the field between September 2012 and March 2013. Tanzania was selected for the pilot intervention because it already conducts similar projects, albeit with different implementation approaches. One of these projects—called SAVVY (Sample vital registration with verbal autopsy) (IFI 2008–2013)—is being carried out in a sentinel panel of 23 of Tanzania's 169 districts selected to provide nationally representative data on demographic and health indicators (Kabadi & Masanja 2012). Another project is the health and demographic surveillance system (HDSS) which operates in three

districts, including the district chosen for the MOVE-IT pilot into mobile health (mHealth) innovation in CRVS (i.e. mCRVS). The HDSS provides a gold standard for determining total birth and death events. Both SAVVY and HDSS systems are built to provide improved monitoring and measurement of vital events but do not yet register events officially in the CRVS. The existence of technology that supports transfer of such information either from HDSS, SAVVY or CRVS will be an asset. The fact that Tanzania is already pioneering the use of mobile phones in the health sector provided an excellent opportunity for developing and testing such an innovative intervention.

Goal of the pilot study

The main goal of the pilot study was to assess how adding an SMS technology process to an existing CR system improves coverage rates and timeliness of registration for birth and death events, and to interpret how applicable these findings are in Africa, Asia and the Pacific.

Objectives of the pilot study

The objectives of the pilot study were to:

- develop a prototype mobile phone SMS platform to integrate into the routine CRVS system at district scale
- increase the coverage rates of registration of births and deaths that occur in one rural Tanzanian district through the use of this SMS technology in an mCRVS strategy
- validate both the conventional CRVS and the mCRVS against the best available estimates of actual births and deaths in the district
- determine the main reasons families fail to complete registration of their births or deaths
- discuss the implications of the pilot study in the wider context of low- and middle-income countries in regions such as Asia and the Western Pacific.

Implementing the intervention

The following steps and processes were taken to implement the intervention.

Overview of the intervention

CR systems are complex, and Tanzania's system is no exception. In Tanzania, CR is managed by the Registration, Insolvency and Trusteeship Agency (RITA) under the Attorney General's Chambers in the Ministry of Justice and Constitutional Affairs. The CR system as it is currently run (and as it was modified by the SMS intervention) is presented graphically in Figure 2, Appendix 1 as a generic diagram for both births and deaths occurring in facilities and at home/elsewhere.

Generally for births at home, the routine CR system requires a relative to report to the Village Executive Officer (VEO) (or that the VEO visit the household); provide details, which are recorded in a ledger; and be issued with a copy of notification, including a serial notification number. The relative has 90 days to submit that notification to the District Civil Registrar's office in the district capital. Again, details are captured in a ledger and the relative is given an invoice to take to the District Cashier's office in the same administrative complex and pay. The relative then returns to the District Civil Registrar and hands in the receipt, then returns in two weeks to obtain the registration certificate. The same basic process applies for community deaths as well, although the relative must report to the registrar within 30 days. Late reporting is subject to penalty charges.

In this pilot, the intention was not to modify the underlying processes described above, since these CR processes must remain intact for legal purposes. Instead, we inserted a real-time information step carried out by the VEO while giving the relative the event notification number and recording the details in the ledger. The MOVE-IT intervention does three additional things:

1. The VEO simultaneously sends the key information for the notification number directly to the District Civil Registrar's computer via a cloud-based customized SMS platform.
2. The system automatically monitors the registrations for the District Civil Registrar to determine if the family reports to the Registrar to complete the certification and registration process within the allowed time period. If not, the system automatically sends a return SMS, informing the VEO of this.

The VEO then must follow up with the family and administer a short questionnaire via the SMS system soliciting the reasons for non-registration. Note that in the routine system, the Registrar would never know that the vital event had taken place.

3. Finally, the system provides an information dashboard to the District Civil Registrar and permitted stakeholders summarising the cumulative registrations and status of the birth and death events passing via the new system.

See section 2.5 and the Appendices for fuller technical details. The SMS intervention steps are shown in Appendix 1 and 2 in grey shading.

The pilot study area

Rufiji District, where this intervention was carried out, is situated along the southern coast of mainland Tanzania, about 180 kilometres from the country's largest city of Dar es Salaam. A number of surveys have been and continue to be conducted in the district for nearly two decades now. The oldest of these is the Rufiji Health and Demographic Surveillance Site (Rufiji HDSS), launched in 1996. The Rufiji HDSS was started mainly to monitor vital events in communities and to generate burden of disease profiles to inform policy in the district and the country. The HDSS now covers 42 villages of the total 111 villages in the district (more details can be found in Mwageni et al. n.d.). Due to the independent availability of high quality data on community-based vital events from the HDSS, Rufiji District was the most favoured study area to pilot the MOVE-IT intervention. MOVE-IT events were reported from 89 of the total 111 villages of the entire district. A total of 22 villages could not report their events during the intervention period due to several challenges described later in the report.

Table 1 summarises the district's projected demographic data for 2012; these figures are compared later with the results from the intervention.

Table 1 Expected demographic statistics for the Rufiji District for six months in 2012

Population	Births	Deaths
253,500	4,310	1,191

Number of villages	Total number of events
111	5,501

Source: NBST 2012; MHSW 2011

Project management, recruitment and training of staff

The MOVE-IT project was supported in conceptualisation and design—including software application development—by the Swiss TPH, who also managed grant subcontracts with the IHI and private sector providers. On the ground in Tanzania, MOVE-IT, through IHI, recruited five staff before starting the pilot study. Those recruited included the MOVE-IT Coordinator (who was responsible for coordinating project activities at the central level) and the Field Supervisor (who was responsible for general implementation oversight of the intervention in the Rufiji District, including administrative, logistical and financial aspects of the MOVE-IT work at field level and for liaison with local leaders and other members of the field team).

In addition, MOVE-IT seconded an Administrative Assistant and a Project Accountant who worked at 10–20% of full-time equivalent and provided back-up support on relevant project activities and managing MOVE-IT project funds. The project also closely involved the Rufiji District's Civil Registrar on a monthly top-up allowance to manage MOVE-IT activities on the government side of operations. Among other things, the Registrar participated in distributing birth and death registers to VEOs of all villages in the district, as well as entering data about certification of vital events in a project computer. General project oversight was by the co-principal investigators Mr Gregory Kabadi, who is the Project Manager for the SAVVY project of the IHI, and Prof. Don de Savigny at the Swiss TPH. Dr Henry

Mwanyika provided general technical and strategic advice on MOVE-IT project implementation.

MOVE-IT activities began with a one-day training event held on 3 September 2012 in Rufiji District. Participants included all system users and data collectors (VEOs at community level; the District Civil Registrar at district level), MOVE-IT personnel, some representatives from the Ministry of Health and Social Welfare and a Technical Advisor from the United Nations Population Fund. The training event was officiated by the Rufiji District Administrative Secretary on behalf of the District Commissioner. A total of 96 (out of 111) VEOs attended and were trained how to report vital events occurring in their communities using the pilot SMS reporting system. The other 15 VEOs who were not able attend were later trained one-one-one by the Field Supervisor. After training, the Field Supervisor followed up with VEOs to establish progress, fix ad hoc problems with use of mobile phones and provide solutions to any other field-related problems.

Field tools

MOVE-IT project purchased two laptops, two mobile phone handsets, and two modems for use by the Field Supervisor and the Rufiji District Civil Registrar to monitor events and to enter and transmit data. The project also borrowed a motorcycle from a sister project of the IHI to help the Field Supervisor navigate through the 111 villages on his regular visits making sure the project ran smoothly.

Notification, registration and certification of events

Notification of an event takes place when an event (a birth or a death) is recorded in the government's community or facility level registry book. For births, the B1 Register is used to record all births in health facilities and the B2 Register is used to record all births occurring outside health facilities. All death events are recorded in the D1 Register, which is also called the 'burial permit'. On notifying events in this pilot, VEOs recorded the event in the respective register and sent a free SMS message of the event's details to the central database linked to the district civil registry. An event was deemed completely notified if the VEO issued the notification form (birth

notification or burial permit) to the respective household and sent the SMS message as required.

In addition to completing the notification process, VEOs instruct household members to visit the District Civil Registrar's office to fully register the event with the district's civil registry and have a certificate issued. If this happens within a period of 90 days since birth or 30 days since death, households pay a fee of TZS 3,500 (equivalent to USD 2.00); there is an extra charge for delayed certification. In this project, all households that had their events issued with certificates within specified periods would have the District Civil Registrar enter their certificate numbers (frequently referred to as entry numbers) into the MOVE-IT central database. Within the database, certified events were matched with notified events for completeness.

If a notified event was not certified within its specified period, a reminder SMS message was sent requesting the relevant VEO to follow up with the respective household and record reasons for non-certification. These reasons were entered into the central database, and included unaffordable cost involved, transport issues to the District Civil Registrar, households being unwilling, a lost notification (without which no certificate will be issued), sickness, households having moved to other districts or reasons unable to be specified. More details of notification and certification processes are given in Appendix 1 and Appendix 2.

Quality assurance (field supervision)

MOVE-IT conducted 10 days of field supervision between 28 November and 7 December 2012 to ascertain the quality of intervention activities and to solve field-related problems. The MOVE-IT Coordinator and Field Supervisor were accompanied by the Rufiji District Civil Registrar, with permission from the District Administrative Secretary. The comprehensive work plan enabled the supervision team to visit all villages and meet with VEOs and health service providers of all health facilities in the district. The supervisory team conducted spot checks on correct formatting of SMS messages and carried out trouble-shooting for VEOs who had notified no or few events prior to the supervision.

Validation of events (using the Rufiji HDSS)

A portion of the notified events that were sent through SMS messages were validated and reconciled with "gold standard" vital event monitoring by the Rufiji HDSS system. This was done for the villages where the pilot intervention and the HDSS system both operated at the same time. As earlier reported, the Rufiji HDSS system operates in 42 of the 111 villages in Rufiji District. This system uses full-time trained surveyors conducting longitudinal surveillance through repeated household visits to monitor populations; register pregnancies; and document births, deaths and causes of death as well as other demographic, socio-economic and health data. This currently constitutes the most accurate demographic data for the population.

SMS platform

The Swiss TPH engaged commercial software and services organisation Greenmash to design an SMS data collection application based on the 'mango' information management platform (Greenmash n.d.). Greenmash, a UK-based company, had previously designed and developed mHealth solutions for a range of healthcare clients in various countries in Africa, including Tanzania. The mango platform for MOVE-IT allows VEOs using any basic mobile phone to send structured text messages about birth and death notifications and registrations to a free number in the system, using any mobile provider. As this is not part of VEOs' normal duties, the project paid a small incentive for this extra work; the mango platform allows this incentive to be paid over the phone if necessary. The District Registrar, with a computer or smartphone with internet access, can see a set of dashboards and reports designed to give the best view of the data.

MOVE-IT pilot project staff were given varied levels of access to the database within the mango platform, which holds information about the number of notifications, the number of registrations and the number of notifications not registered. The mango system also supports process automation and workflow, which was used to alert VEOs if a notified event had not been registered within a given time period, enabling them to follow up to identify the reasons for this. In addition to the summary reports, the mango dashboard also provides response levels, historical levels and activity logs. It can also extract data to either portable document format or Microsoft Excel format.

In the example of a female child born at home on 27 January 2011, being issued with a notification number of 0000264515, the SMS string format for the birth notification was as follows:

BIRTH0000264515 T2SFD20110127

Where:

- 0000264515 = the notification number
- T1 = health facility event
- T2 = outside health facility event
- SF = sex female
- SM = sex male
- D20110127 = Date as year/month/day.

Similarly, the SMS format for a death notification was as follows:

DEATH0000264515 T2SFD20110127

with similar notation as in the birth notification format above.

In essence, the mango platform for mCRVS allows basic mobile phones in remote peripheral villages to interface with and exchange data with computers in the District CRVS system. A selection of screen shots of the dashboard and system outputs is provided in Appendix 3.

Data analysis

To evaluate the intervention's impact, events notified and certified by the District Civil Registrar in the corresponding six months exactly 12 months prior to the intervention were compared with those reported during

the six-month intervention (Table 2 and Table 3). The number and type of reasons for non-certification were presented in tables categorised by birth or death (Table 4). In addition, the number of events reported by the SMS intervention was compared with those reported by the Rufiji HDSS (Figure 1 and Appendix 4).

Ethical clearance

Ethical clearance was issued internally by the IHI's Institutional Review Board before the intervention began, based on the similarity in operational approaches to those of the SAVVY project. Ethical clearance for the SAVVY project (also of the IHI) was issued in 2010 by the National Institute for Medical Research for operation in 23 districts of mainland Tanzania.

Results

The main results of the intervention are divided in three parts: the number of events (births and deaths) notified during the six months of intervention, the number of events issued with certificates by the District Civil Registrar, and reasons reported by households for failure to certify their events during the six months of the intervention.

Notification of births and deaths

Table 2 shows the number of events notified during the six-month period of the intervention and those notified during the same six-month period a year before the intervention. The number of births notified during the intervention period nearly doubled from 564 births to 1048 (186% increase) while the number of deaths notified rose more than five-fold, from 29 to 165 (569% increase). Of the six months of intervention, the fourth month, December 2012, had many more events notified than in other months, with 301 births and 44 deaths. All months of the intervention had more events reported and notified except for the last month of February 2013 where the number of births notified before the intervention was higher than those notified during intervention period. The number of notified deaths was the same in the sixth month of the intervention as that without the intervention a year before.

Table 2 Number of events notified in seasonally matched periods before and during the six-month SMS intervention period

Month	Number of births notified		Number of deaths notified	
	2011/2012	2012/2013	2011/2012	2012/2013
	CRVS	CRVS + SMS	CRVS	CRVS + SMS
September	30	111	1	32
October	89	102	1	15
November	156	218	1	42
December	80	301	1	44
January	83	201	14	21
February	126	115	11	11
Total	564	1,048	29	165

Note: From Table 1, the demographically expected number of events in a six-month period in Rufiji District in 2012 was 4,310 births and 1,191 deaths, assuming even distribution throughout the year.

Certification and registration of birth and death events

The number of notified events submitted to the District Civil Registrar for issuance of certificates during the six-month period of intervention is shown in Table 3. There was a slight increase of the number of certificates issued for birth events from 285 to 312 (about a 9% increase). Likewise, the number of certificates issued for death events rose from 13 events to 19 (a 46% increase). Despite the overall increase in certifying events, half of the intervention period (three months) had fewer certificates issued for births compared to the same period a year before the intervention.

The number of birth certificates issued before the intervention was only about half (50.5%) of the number of notified births of the same period. The number of issued birth certificates during the intervention was lower than a third of all birth events notified during the period, at 30%. Also, the number of death certificates issued before the intervention period was less than half (45%) of all notified death events of the same period. During the intervention period, the number of death certificates issued was just over a tenth (11.5%) of all death events notified. This means that despite the increased numbers of notifications in the intervention period, fewer of these reported for certification.

Table 3 Number of events certified before and during the SMS intervention period

Month	Number of births registered		Number of deaths registered	
	2011/2012 CRVS	2012/2013 CRVS + SMS	2011/2012 CRVS	2012/2013 CRVS + SMS
September	55	85	2	3
October	51	21	2	1
November	19	63	3	1
December	49	68	2	5
January	45	19	2	4
February	66	56	2	5
Total	285	312	13	19

Reasons for non-certification

The reasons for failure of households to have their vital events issued with certificates from the District Civil Registrar are presented in Table 4. For births and deaths respectively, 409 and 49 households responded to the question about non-certification. Household members were asked to state the reasons they could not have their already-notified vital events issued with certificates during the non-penalty period, which for birth events is 90 days and for death events is 30 days, beyond which a modest fee is charged for late certification. Of the 409 households reporting their reasons for not certifying birth events, 140 (34%) had no specific reasons. Other main reasons attached to non-certification of birth events were transport issues (21%), unwillingness (12%) and the issue of involving cost during the process (12%).

Of the 49 households reporting their reasons for not certifying their death events, 16 households (33%) were reported by the VEO to have moved out of the district

after the death event. This is not uncommon in Tanzania following death of a member of the household. Other households reported their reasons to be related to transport issues (31%) and unwillingness to have events certified (29%). Only a handful (6%) of households reported cost to be the reason for not certifying a death event to the District Civil Registrar, although cost considerations are likely to be included in the responses indicating transport issues, since transport in Tanzania is costly for the poor.

It appears from this work that it is easy to increase the number of notifications using the SMS intervention but this does not translate directly into an increase in families reporting for certification. Perhaps this is because CEOs were being more proactive in notifications due to the intervention, but that these notifications were from households less likely or motivated to certify. Clearly, more work is needed if the model of reporting to the District Civil Registrar is the only way that certification can be achieved.

Table 4 Number and type of reasons for households' failure to certify their events

Reasons for non-certification					
Births			Deaths		
Reason	Number	%	Reason	Number	%
No specific reasons	140	34%	Household moved out of district	16	33%
Transport issues	87	21%	Transport issues	15	31%
Cost issues	49	12%	Household was unwilling	14	29%
Household was unwilling	49	12%	Cost issues	3	6%
Sickness	40	10%	Sickness	1	2%
Household moved out of district	25	6%	No specific reasons	0	0%
Household lost notification	12	3%	Household lost notification	0	0%
Child died before 90 days	7	2%	Child died before 90 days	n/a	n/a
Total	409	100%	Total	49	100%

Reconciliation of SMS-reported events versus Rufiji HDSS-reported events

Table 4 presents the number of events reported using the SMS intervention in the MOVE-IT pilot project compared to those reported by the “gold standard” HDSS operating in 42 villages of Rufiji District.

During the same reporting period between September 2012 and February 2013, Rufiji HDSS reported nearly double (916) the birth events reported by MOVE-IT (468) for the same villages and time period. The Rufiji HDSS reported more than seven times (379) the death events reported by MOVE-IT (54) during the same six-month period.

Events from all reporting villages in Rufiji district can be seen in Appendix 4, although the Rufiji HDSS events in the appendix cover only for the period from September 2012 to January 2013. Rufiji HDSS numbers for February 2013 were received as monthly aggregates and did not include the list of villages from where they were reported. The totals shown in Figure 1, however, cover the full period through to February 2013.

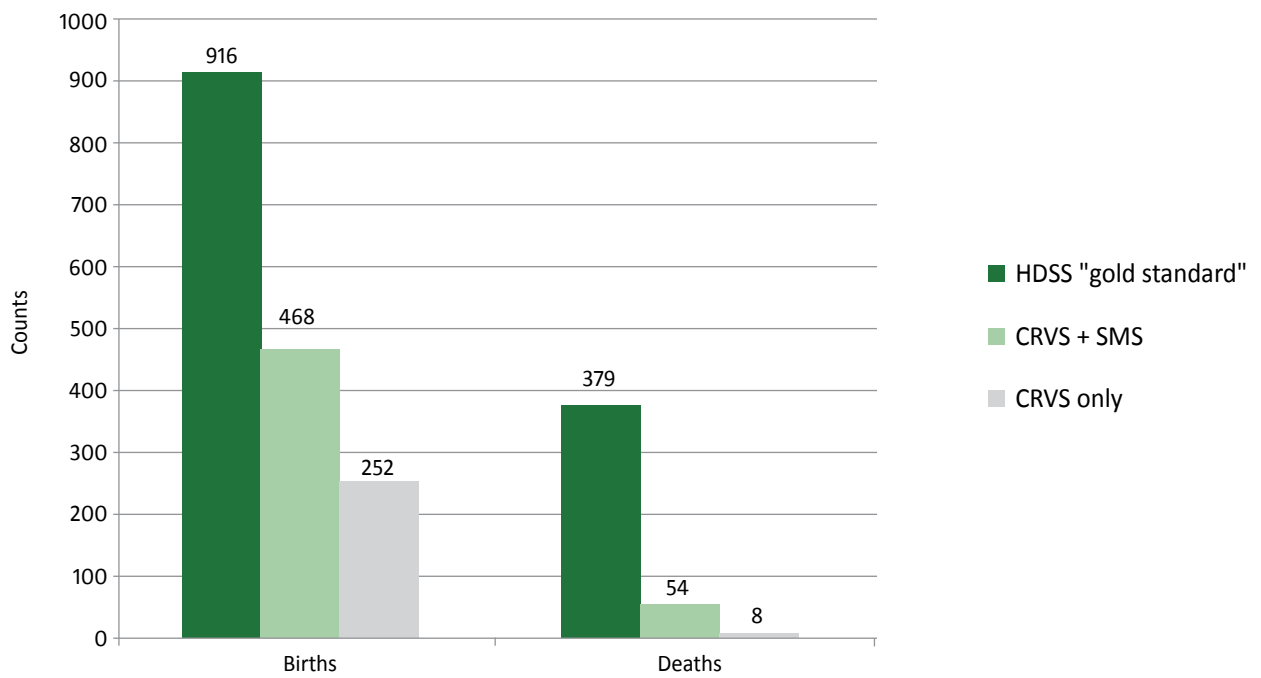


Figure 1 Reported events documented by the Rufiji HDSS (gold standard), by CRVS+SMS (Sep 2012 – Feb 2013) and by the routine CRVS reporting system in the same period of the prior year (Sept 2011 – Feb 2012)

Note: These events are from a subset of 42 villages where the Rufiji HDSS system overlaps with villages where MOVE-IT events were reported.

Lessons of the MOVE-IT pilot study

Key findings

The routine CRVS was found to notify only 28% of births and registers even fewer. Adding the SMS step increases this to 51% of births notified, but only marginally improves registrations. The routine CRVS detects only 2.1% of deaths and registers even fewer. Adding the SMS step significantly increases this to 14% of deaths but only marginally improves registrations. **The SMS intervention makes significant improvements in the notification step and modest improvements in the registration step of routine Civil Registration.** However, both notifications and registrations still fall well short of reality. The most important finding, therefore, is the demonstration and verification of the profound weakness in the underlying CRVS notification and registration coverage. The MOVE-IT pilot project provides evidence that CRVS processes in Tanzania will require much more radical redesign to improve performance and will be greatly assisted by an mCRVS component.

Scalability potential

As described above, in the seasonally matched periods from September 2011 to February 2012 without the SMS intervention to September 2012 to February 2013 with SMS intervention, notified birth events increased about two-fold from 564 to 1048 (186%), and notified death events increased about five-fold from 29 to 165 (569%). Despite these relative improvements, in absolute terms, the SMS assisted CRVS still missed about 50% of the birth events and about 85% of the death events compared to actual events reported by the longitudinal follow-up system of the Rufiji HDSS. It is important to note, however, that the longitudinal follow-up system employed by the Rufiji HDSS has operated in these 42 villages for more than 15 years, compared to the six-month period of the pilot intervention.

Overall, **results of this intervention show encouraging signs of a scalable innovation to accelerate and increase coverage of CR in a developing country.** The intervention provides visibility of vital events information to the District Civil Registrar (and any other authorised users) in real time and includes the opportunity to simplify and strengthen the process. Given a longer period of implementing the survey, the intervention could have increased its usefulness and ease of reporting by VEOs. It could potentially have matched the longitudinal

reporting system, with its added advantage of speedy event transmission, cheaper operating cost and simplified management by district authorities.

The pilot intervention has also managed to uncover and report the reasons that prevent households having their notified events issued with certificates. Birth and death certificates are more important than notifications, in terms of their application. These results have shown that even though notification of events increased before and during the intervention period, issuance of certification was unprecedentedly low.

The challenges faced and foreseeable

This MOVE-IT pilot project encountered several challenges, most of which were comprehensively resolved by the field team and so helped increase notification of vital events. Some of these key challenges and how they were eventually resolved are described below:

- a) The intervention engaged government civil servants, the VEOs, to report community vital events. This is different from the longitudinal follow-up systems such as the Rufiji HDSS and the Tanzanian SAVVY system, which both use community key informants plus professional household interviewers three times per year at each household. Due to their other duties, VEOs could sometimes have little or no time to follow up events in households in their villages. Some VEOs were more likely to wait for parents of a newborn child or relatives of the deceased to come to their offices for the notification. Community key informants as used in the Rufiji HDSS, on the other hand, do frequent visiting of households as part of their day-to-day activities. The HDSS village key informants are not salaried, but get a commission or incentive for each vital event which is confirmed by the system. The routine CRVS might consider this commissioned approach using non-salaried key informants plus SMS, rather than VEOs, to increase the coverage of notifications.
- b) Of the major mobile phone operators in the district, Airtel had coverage in nearly all villages, whereas other operators such as Tigo and Vodacom only covered about 50% of the villages in the district. In addition, more than 90% of all reporting VEOs used Airtel for their private mobile phones. It took

nearly half the MOVE-IT pilot period to have Airtel sign contractual agreements, causing a significant number of events to go unreported through the intervention's SMS system. This could explain some of the discrepancy between the SMS-reported events and the HDSS-reported events.

- c) Only 89 of 111 villages participated. This was because not all villages could send the events (mainly villages located in the tidal delta area) due to the absence of mobile phone network coverage. A few villages did not have their own or an acting VEO and could not participate.
- d) There were two minor issues reported with the system: one was a data validation step, which caused a delay in data processing for a few days in December; the other was a data extract issue in January, which was resolved on the same day it was reported. Despite these two minor issues there was no loss of data.
- e) The most important finding of this pilot is that the current CRVS system in at least Rufiji District, and likely most of rural Tanzania, is essentially unable to provide adequate registration coverage for births and deaths, and that coverage is so low that even log order improvements are insufficient to lift it to satisfactory levels (in excess of 90% of events). This says nothing as yet regarding the quality of the data. No overwhelming reason is provided by families for the low reporting rate, suggesting that the problems are highly systemic and will need a radical redesign of processes. It is clear that whatever these processes will be, some form of real-time mobile communication will greatly facilitate coverage levels.

Innovation potential for mCRVS in low- and middle-income countries

The space for innovation

Most low- and middle-income countries are moving rapidly into the innovation space created by the information and communications technology revolution, especially the recent cloud-based resources of the internet, and the astonishing penetration of mobile phones to the most remote and poorest populations. Governments are establishing e-Government (where 'e' stands for 'supported by electronic processes and communication') standards, and individual ministries are developing sectoral strategies (e.g. eHealth and mHealth strategies in the health sector). Latecomers on this scene are the ministries most responsible for CRVS (the ministries of justice or internal affairs). The heavy reliance on physical movement of paper-based processes to a relatively small number of non-networked computers has meant that this function of government has, as yet, failed to capitalise on this revolution, and the CRVS scene has been in general stagnation for decades.

Tanzania is thus typical of where many low- and middle-income countries are with use of eCRVS (use of electronic databases and computers for CRVS) and mCRVS, a more recent opportunity. The results of this pilot point out just how weak the conventional paper-based CRVS and eCRVS systems and present processes are.

Current status and potential of mCRVS

The mobile phone grid of the world now exceeds the electrical grid (WHO 2011). Mobile phone connectivity of the poorest and most remote populations on earth is astonishing in the pace and high coverage achieved in recent years. The potential being created through the rapid advances in mobile technologies and their interoperability with modern data systems represents not merely a simple automation of a paper-based birth or death registration system, but offers the opportunity for a radical transformation of the business processes of how birth and death registration takes place.

The results reported in this small-scale pilot study in a typical CRVS system in a low-income country are the first to validate coverage levels against gold standard longitudinal demographic surveillance data. The events captured by the conventional CRVS system are only about 28% of actual birth events and 2% of actual death events. There has been dramatic improvement in notifications following the introduction of a simple

and potentially low-unit-cost SMS step. However, even dramatic improvements from such a low starting point are insufficient. We must therefore resist the usual temptation to take these gains and scale up —the intervention.

What these results drive home is the need for an end-to-end overhaul of the architecture and processes of how CRVS systems are built and integrated into the information fabric of some countries. Small incremental technical fixes will not suffice.

That said, the emerging potential of capturing and transmitting, in real time, key data on births and deaths via mobile devices is enormous, and in itself, should provide the motivation for CRVS managers and policy-makers to embark on ambitious plans to redesign CRVS systems with totally new e- and m-components in line with open government standards.

Unfortunately, coherent and integrated progress is impeded by the multiplicity of authorities and ministries with a stake in CRVS. The result for much of the developing world is a scene of fragmented efforts. In consequence, attempts at innovation are often small-scale incremental pilot experiments. Few of these innovations are ever taken to national scale.

A recent, as yet unpublished, systematic review of eCRVS and mCRVS innovations (pers. comm. Jane Thomason of Health Metrics Network) found that most historical effort has been devoted to increasing the computerisation of CRVS data collection and provision of birth and death certificates (eCRVS). Very few examples of mCRVS experiments were found.

The Health Metrics Network has been an important champion of strengthening CRVS systems through its funding of MOVE-IT. This effort has collected together a number of disparate approaches to innovate in various aspects of CRVS. A few of these involved the use of mobile technologies (Ethiopia, Ghana, Kenya and Rwanda). However, many of the mCRVS initiatives proposed by countries were not explicitly directed towards registering births and deaths, but in many cases were focused on health worker activities such as tracking pregnant mothers and child immunisation and on disease- or risk-specific outcomes, reflecting the dominant interests of the health sector. Some of the projects focused on notifying community births, but less so on the next step of how this notification is translated to a legal birth registration as was done in this pilot study.

None of the projects fully addressed death notification, certification or registration with cause of death. In consequence, these projects did not address the core CRVS system as a whole, but only parts of it. There are as yet no publications of these experiences.

The need for an enterprise architecture approach

The problem with working on only a part of the system is that such mCRVS projects are not able to take account of the institutional and behavioural complexity associated with CRVS.

To move past the tyranny of an incremental approach, it will be necessary to adopt an enterprise architecture framework with open standards and an open software approach to guide the development and implementation of an integrated national CRVS. In such an approach, it will be necessary to see both the eCRVS and mCRVS contributions as a whole. CR can be seen as the backbone and purpose to which everything joins. Inputs to this would come in different forms from different sources, including birth and death records from health facilities, systems for birth and death notification (such as shown in this community- or facility-based SMS system), cause-of-death information from facilities and verbal autopsies, sample and sentinel registration systems, unique identification schemes and social security systems.

The enterprise architecture approach will be necessary to fuse both the technical (hardware/software) with the process flows and use cases that specify how inputs are generated and arrive in the system, and how outputs (data repositories, certificates and vital statistics) are generated for the public and for users. All of this is shaped by the legal, regulatory and political frameworks that form the context for CRVS in each country. For example, outputs are required for security purposes, passport offices, insurance and universal health and pension coverage entitlements, burden of disease and other health and demographic statistics. Rwanda is one of the first countries to start adopting an enterprise architecture approach to planning for CRVS, including an mCRVS approach for community vital events linked into a national system.

It is clear from this pilot study that the current process flows in Tanzania simply for birth and death registration, let alone cause of death, are incompatible with the behaviours of families experiencing the birth and death events that they are expected to bring forward for certification, even if they are issued with a notification number. Such systems are designed to fail no matter what technology efficiency gains can be applied.

The multiple stakeholder and multiple ministerial interests, along with the need for integration and scalability, simply add weight and inevitability to taking an enterprise architecture approach to CRVS. **What enterprise architecture brings is a systems-thinking approach to managing these profound complexities.** This cannot be accomplished by driving change primarily through a technical innovation such as mobile communications and the replacement of paper flows with electronic data flows. The entire set of processes in most low-income countries will need to be reconsidered and redesigned. However, the promise, interest and innovation energy around mCRVS may be exactly what is needed to motivate the stewards of CRVS systems to decide to take the step towards a major reformation rather than hoping for incremental change based only on new technology.

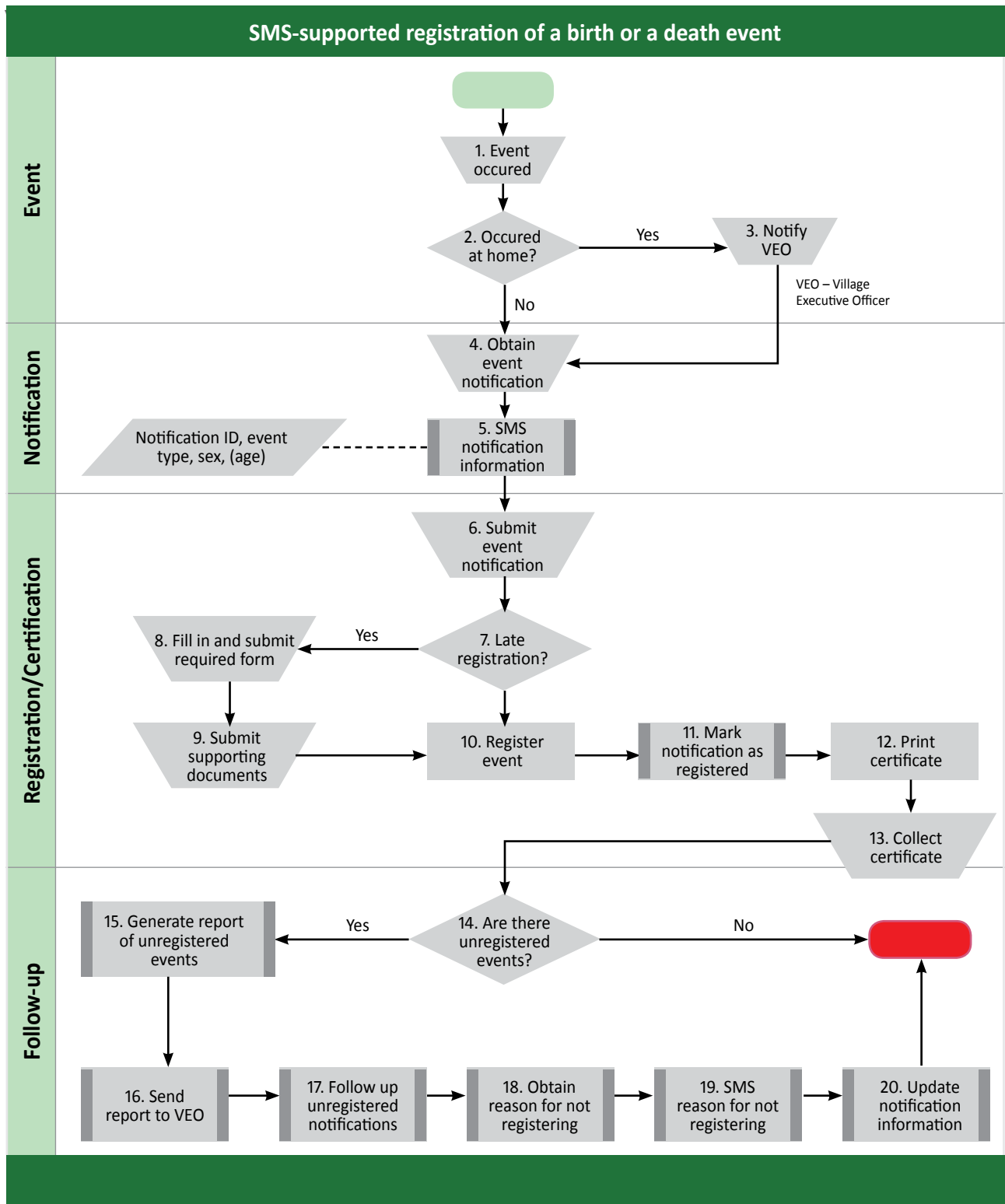
Appendix 1: Birth registration – detailed procedure of MOVE-IT intervention

(supplemental SMS activities highlighted)

1. Birth occurs
2. Obtain notification
3. If a birth occurs in the health facility the health worker fills in the birth notification form in a book of pre-assigned serial numbers and gives the original to the mother or relative and keeps a copy in the book
4. If a birth occurs at home, the relative should report the birth to the VEO or District Civil Registrar who fills in the birth notification form in a book with pre-assigned serial numbers and gives the original to the mother or relative and keeps a copy in the book
5. SMS with notification details is sent to the mango system with the following information: **notification ID, event type, sex of the child, date of event**
6. The relative takes the birth notification obtained above to the District Civil Registrar of the district where the birth occurred
7. District Civil Registrar takes the notification form and verifies that all information is filled in correctly
8. If the birth occurred more than 90 days ago the birth is considered as late registration and the relative must then provide additional documentation, fill in additional forms and pay late registration fee
9. If the birth occurred within 90 days, the relative is given a notification for payment and asked to go to the cashier for payment and to take the receipt back to the District Civil Registrar
10. Once confirmation of payment is received, the District Civil Registrar registers the birth into a computer system and asks the relative to return in two weeks to collect the birth certificate
11. Birth notification in mango system is marked as registered and the record updated with birth certification number
12. District Civil Registrar prints the birth certificate
13. Relative goes back to the District Civil Registrar to collect the certificate
14. Mango system will check if there are unregistered notifications
15. If there are notifications that are not marked as registered the system will generate a report
16. The system sends a report to the VEO of the corresponding village by SMS
17. VEO follows up reason for non-registration and encourages registration
18. VEO sends an SMS of the reason
19. Mango system updates the notification record with the reason.

Figure 2 below illustrates the procedure for registering a birth or death event.

Figure 2 Registration process for birth and death events in Tanzania



Symbols and meanings

- Event begins
- Event ends
- Activity performed by mango system /VEO
- Activities performed by RITA system for CVRS
- Description of information
- Decision point
- Activity performed by a relative

Appendix 2: Death registration – detailed procedure of MOVE-IT intervention

1. Death occurs
2. Family member obtains burial permit
3. If a death occurs in the health facility the health worker fills in the burial permit form in a book of pre-assigned serial numbers and gives the original to the relative and keeps a copy in the book
4. If a death occurs at home, the relative reports the death to the VEO or District Civil Registrar who fills in the burial permit in a book with pre-assigned serial numbers and gives the original to the relative and keeps a copy in the book
5. SMS with burial permit details is sent to mango system with the following information: **burial permit ID, event type, sex of the deceased, date of event**
6. The relative takes the burial permit obtained above to the District Civil Registrar of the district where the death occurred.
7. District Civil Registrar takes the burial permit and verifies that all the information is filled in correctly
8. If is the death occurred more than 30 days ago the death is considered as late registration and the relative must then provide additional documentation and fill in additional forms
9. If the death occurred within 30 days, the relative is given a notification for payment and asked to go to the cashier for payment and to take the receipt back to the District Civil Registrar
10. Once confirmation of payment is received the District Civil Registrar registers the death into a computer system and asks the relative to return in two weeks to collect the death certificate
11. Burial permit information in mango system is marked as registered and the record updated with death certification number
12. District Civil Registrar prints the death certificate
13. Relative goes back to the District Civil Registrar to collect the certificate
14. Mango system will check if there are unregistered burial permits
15. If there are burial permits that are not marked as registered the system generates a report
16. The system sends a report to the VEO of the corresponding village by SMS
17. VEO follows up reason for non-registration
18. VEO sends an SMS of the reason
19. Mango system updates the burial permit record with the reason.

Figure 2 above illustrates the procedure for registering a birth or death event.

Appendix 3: Screen shots of the mango platform

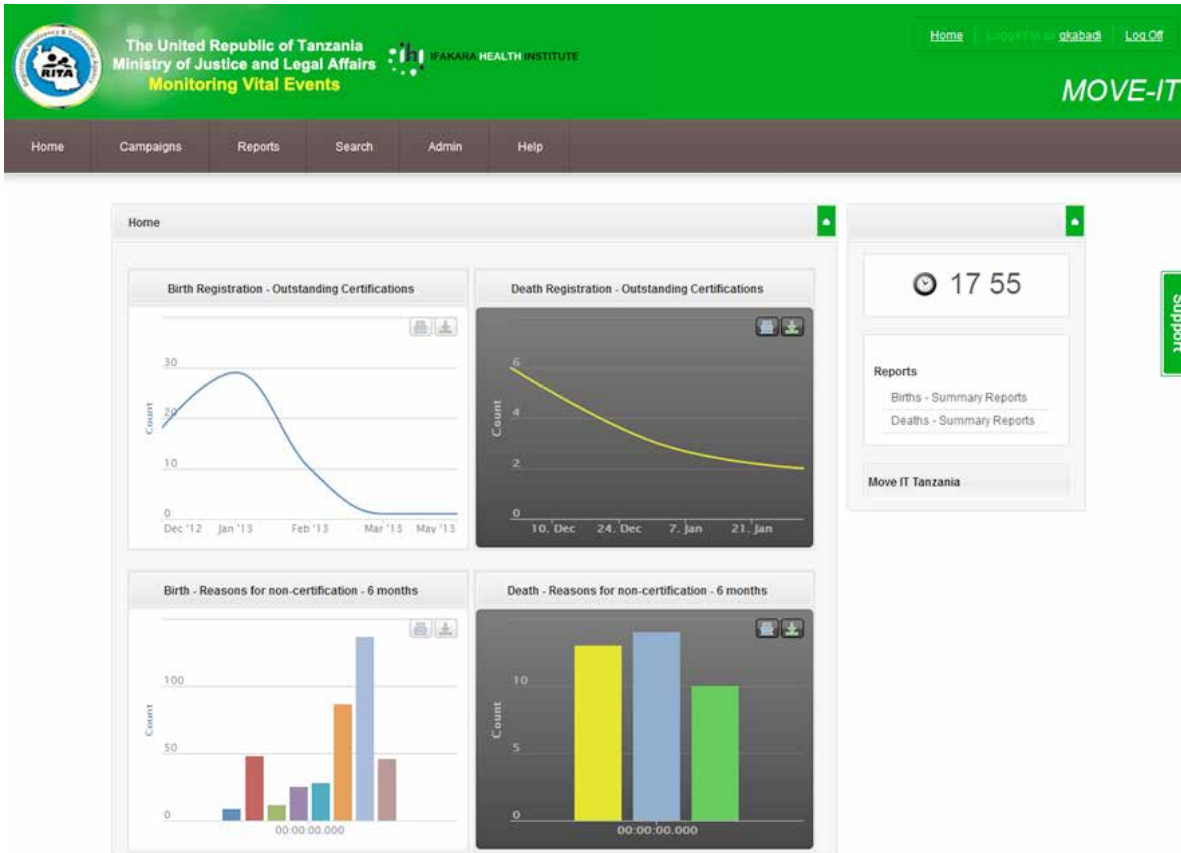


Figure 3 Mango MOVE-IT platform primary dashboard

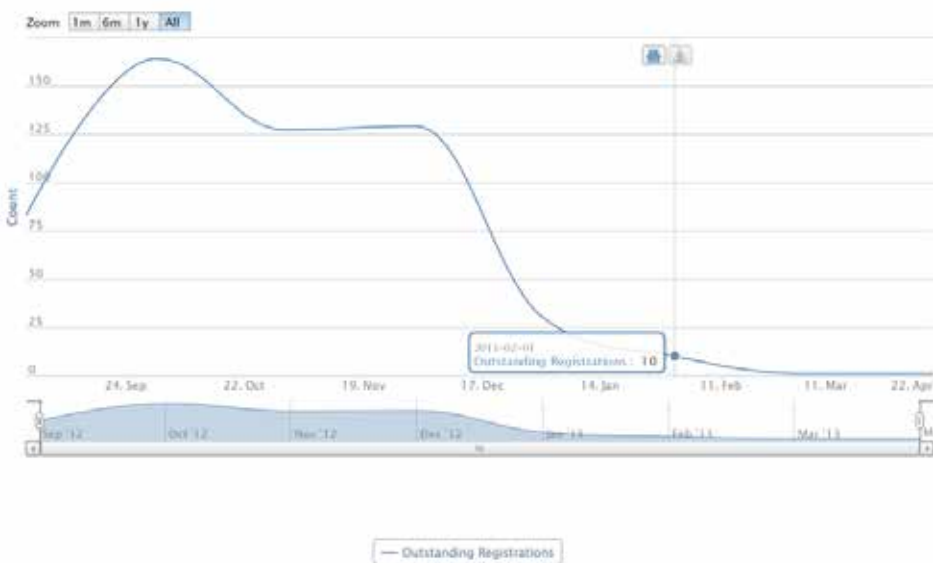


Figure 4 Births reporting, notifications not registered

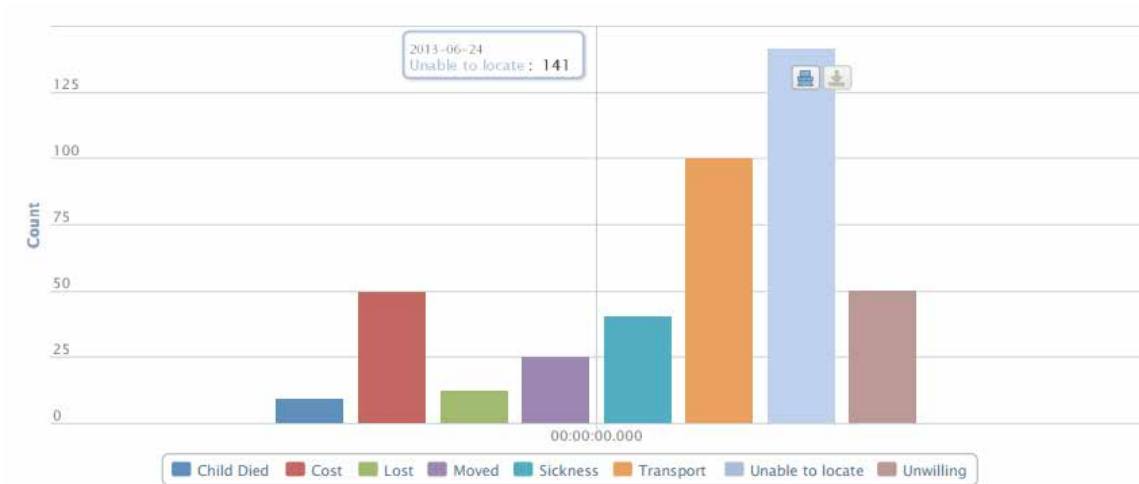


Figure 5 Births reporting, reasons for non-registration

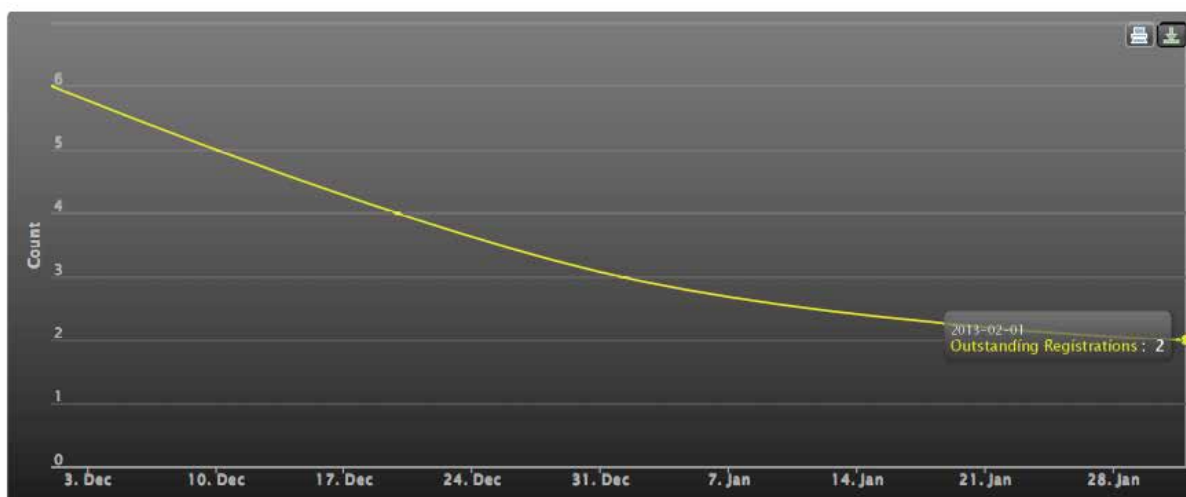


Figure 6 Deaths reporting, notifications not registered

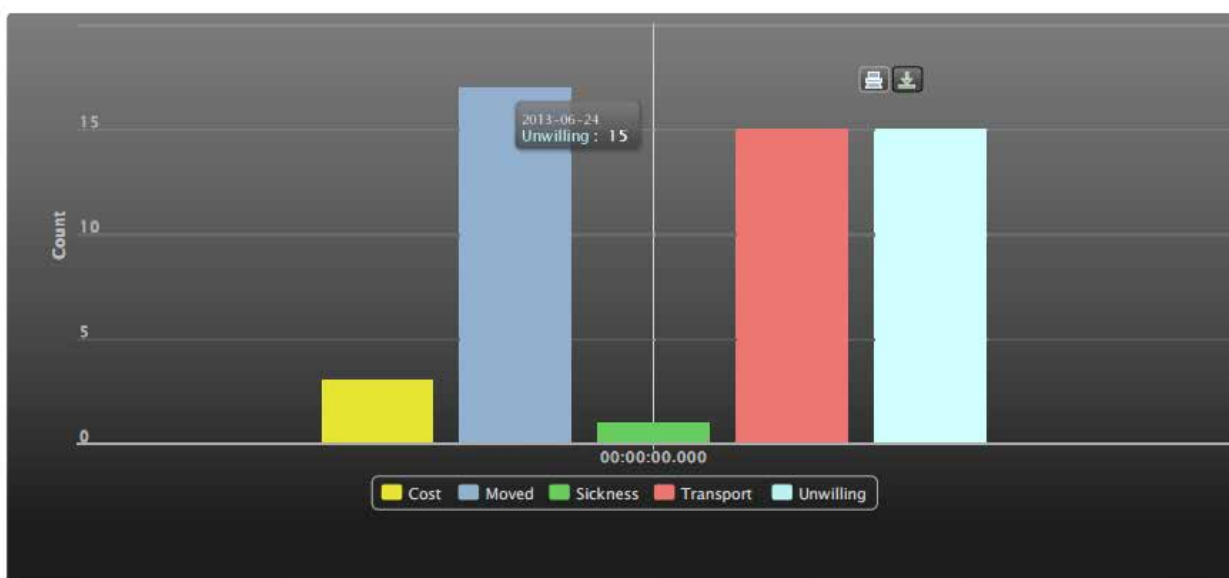


Figure 7 Deaths reporting, reasons for non-registration

Appendix 4: Events reported by type and village through MOVE-IT and Rufiji HDSS

Note: RUFJI HDSS = Sep 2012 to Jan 2013

S/N	VILLAGE NAME	MOVE-IT Births	RUFJI HDSS BIRTHS	MOVE-IT Deaths	RUFJI HDSS DEATHS
1	KIBITI B	195	73	0	23
2	JARIBU MPAKANI	89	65	10	11
3	BUNGU B	3	38	1	16
4	MLANZI	8	33	0	14
5	KIBITI A	9	32	0	13
6	MTAWANYA A	1	32	4	20
7	BUNGU A	5	30	0	13
8	UMWE CENTRAL	8	24	0	12
9	UMWE NORTH	30	20	3	12
10	MGOMBA SOUTH	6	19	1	7
11	KINYANYA	12	18	2	7
12	PAGAE	11	18	2	10
13	MCHUKWI A	8	17	5	11
14	RUARUKE B	1	17	6	5
15	MCHUKWI B	0	14	0	8
16	IKWIRIRI SOUTH	1	13	4	13
17	MGOMBA NORTH	0	12	0	3
18	IKWIRIRI NORTH	10	11	3	2
19	RUNGUNGU	0	11	0	2
20	UMWE SOUTH	0	11	0	2
21	MWANGIA	8	10	1	2
22	NGULAKULA	2	10	0	3
23	NYAMBUNDA	10	9	0	4
24	MACHEPI	3	8	0	1
25	RUARUKE A	4	8	1	1
26	UPONDA	11	7	0	0
27	KILULATAMBWE	0	6	0	1
28	MGOMBA CENTRAL	0	6	0	1
29	MJAWA	9	5	1	3
30	MSAFIRI	1	5	5	5
31	NYAMBILI	4	5	1	2
32	NYAMATANGA	0	5	0	1
33	NYAMWIMBE	0	5	0	3
34	KIMBUGA	1	4	0	9
35	MNG'ARU	0	4	1	1
36	MOTOMOTO	2	4	0	2
37	IKWIRIRI CENTRAL	5	3	1	4
38	MIWAGA	1	3	0	4
39	MKUPUKA	3	3	1	1
40	UCHEMBE	0	3	0	0
41	BUMBA/MSORO	7	2	1	1
42	MANGWI	0	2	0	2
Subtotal, MOVE-IT & RUFJI HDSS		468	625	54	255

43	CHUMBI A	5	n/a	1	n/a
44	CHUMBI B	0	n/a	2	n/a
45	HANGA	12	n/a	4	n/a
46	JAJA	0	n/a	1	n/a
47	KIKALE	8	n/a	0	n/a
48	KILIMANI MAGHARIBI	1	n/a	0	n/a
49	KILIMANI MASHARIKI	0	n/a	1	n/a
50	KIOMBONI	21	n/a	8	n/a
51	KIPO	14	n/a	2	n/a
52	KIPUGIRA	4	n/a	0	n/a
53	KIVINJA A	4	n/a	0	n/a
54	KIVINJA B	1	n/a	0	n/a
55	MAEGE	10	n/a	0	n/a
56	MANGOMBELA	15	n/a	0	n/a
57	MBUCHI	8	n/a	2	n/a
58	MBUNJU MVULENI	2	n/a	0	n/a
59	MBWALA	9	n/a	0	n/a
60	MBWERA MAGHARIBI	5	n/a	7	n/a
61	MBWERA MASHARIKI	5	n/a	0	n/a
62	MCHINGA	9	n/a	0	n/a
63	MCHUNGU	8	n/a	2	n/a
64	MFISINI	8	n/a	1	n/a
65	MHORO MAGHARIBI	0	n/a	3	n/a
66	MHORO MASHARIKI	5	n/a	5	n/a
67	MIBUYU SABA MWASENI	2	n/a	6	n/a
68	MKENDA	3	n/a	1	n/a
69	MKONGO KASKAZINI	1	n/a	5	n/a
70	MLOKA	2	n/a	4	n/a
71	MSALA	7	n/a	0	n/a
72	MTANZAMSONA	6	n/a	3	n/a
73	MTAWANYA B	3	n/a	3	n/a
74	MTUNDA A	6	n/a	0	n/a
75	MTUNDA B	11	n/a	0	n/a
76	NAMBUNJU	17	n/a	0	n/a
77	NGARAMBE	28	n/a	1	n/a
78	NGONDAE	3	n/a	0	n/a
79	NGORONGO MAGHARIBI	11	n/a	2	n/a
80	NYAKINYO	1	n/a	1	n/a
81	NYAMINYWILI	1	n/a	0	n/a
82	NYAMISATI	21	n/a	1	n/a
83	NYAMWAGE	26	n/a	3	n/a
84	NYANJATI	9	n/a	1	n/a
85	POMBWE	2	n/a	0	n/a
86	TAPIKA	11	n/a	0	n/a
87	TAWI	2	n/a	0	n/a
88	TOMONI	14	n/a	1	n/a
89	UTETE MAGHARIBI	239	n/a	40	n/a

90	CHUMBI C	0	n/a	0	n/a
91	KIASI	0	n/a	0	n/a
92	KIECHURU	0	n/a	0	n/a
93	KIGUNGULI	0	n/a	0	n/a
94	KING'ONGO	0	n/a	0	n/a
95	KIONGORONI	0	n/a	0	n/a
96	KITAPI	0	n/a	0	n/a
97	KIWANGA	0	n/a	0	n/a
98	MAPARONI	0	n/a	0	n/a
99	MKONGO KUSINI	0	n/a	0	n/a
100	MSINDAJI	0	n/a	0	n/a
101	MUYUYU	0	n/a	0	n/a
102	NDUNDUNYIKANZA	0	n/a	0	n/a
103	NDUNDUTAWA	0	n/a	0	n/a
104	NGALENGWA	0	n/a	0	n/a
105	NGORONGO MASHARIKI	0	n/a	0	n/a
106	NYANDAKATUNDU	0	n/a	0	n/a
107	ROMA	0	n/a	0	n/a
108	RUWE	0	n/a	0	n/a
109	TUASALIE	0	n/a	0	n/a
110	UTETE MASHARIKI	0	n/a	0	n/a
111	UTUNGE	0	n/a	0	n/a
All 111 villages, MOVE-IT ONLY		1048		165	

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The Knowledge Hubs for Health Initiative

The Health Information Systems Knowledge Hub is one of four hubs established by AusAID in 2008 as part of the Australian Government's commitment to meeting the Millennium Development Goals and improving health in the Asia and Pacific regions. All four hubs share the common goal of expanding the expertise and knowledge base to help inform and guide health policy.

The Knowledge Hubs are funded by AusAID's Strategic Partnership for Health Initiative.

Health Information Systems Knowledge Hub

The University of Queensland

Aims to facilitate the development and integration of health information systems into the broader health system strengthening agenda, and increase local capacity to ensure that cost-effective, timely, reliable and relevant information is available. The Health Information Systems Knowledge Hub also aims to better inform health information systems policies across Asia and the Pacific.
www.uq.edu.au/hishub

Human Resources for Health Knowledge Hub

The University of New South Wales

Aims to contribute to the quality and effectiveness of Australia's engagement in the health sector in the Asia–Pacific region by developing innovative policy options for strengthening human resources for health systems. The hub supports regional, national and international partners to develop effective evidence-informed national policy-making in the field of human resources for health.
www.hrhub.unsw.edu.au

Health Policy and Health Finance Knowledge Hub

*The Nossal Institute for Global Health
(University of Melbourne)*

Aims to support regional, national and international partners to develop effective evidence-informed national policy-making, particularly in the field of health finance and health systems. Key thematic areas for this hub include comparative analysis of health finance interventions and health system outcomes; the role of non-state providers of health care; and health policy development in the Pacific.
www.ni.unimelb.edu.au

Compass: Women's and Children's Health Knowledge Hub

Compass is a partnership between the Centre for International Child Health, The University of Melbourne, Menzies School of Health Research and Burnet Institute's Centre for International Health.

Aims to enhance the quality and effectiveness of women's and children's health interventions and focuses on supporting the Millennium Development Goals 4 and 5—improved maternal and child health, and universal access to reproductive health. Key thematic areas for this hub include regional strategies for child survival; strengthening health systems for maternal and newborn health; adolescent reproductive health; and nutrition.
www.wchknowledgehub.com.au



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