Enhancing Community Based Health Information System (CBHIS) Reporting Through Open-Source Short Message Service-Based Tool

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Abstract: Evidence-based strategic decisions, planning, budgeting, policy formulation at different health care levels can be made possible with complete, accurate, timely health information. However, manual reporting forms continues to increase frequency of errors and workload of community health volunteers (CHVs). Mobile penetration rate standing at 79.2% in Kenya has been seen as a potential technology avenue to improve current CBHIS process flows. We thus designed and piloted a simple SMS-Based reporting system for the CHVs and assessed its impact to improve timeliness in reporting, arithmetic accuracy, data completeness, cost in Kinamba Community Unit. The system helped reduce annual transport cost by 97%, over 3 days' time saving collating the data, improved CHVs reporting rate by 16% for 3-month period, eliminate inaccurate manual aggregation according to the 94% users in agreement. This research therefore recommends self-sustaining open source technologies for efficient and easy data collection, transmission and analysis systems for quicker response.

Keywords: CHVs, CBHIS, data, SMS, CHEW, open source tools.

1. Introduction

Presence of reliable and timely health information is regarded as an essential foundation influencing public health action as well as strengthening the health system both nationally and internationally [10]. However, building an effective strong health system in Kenya has over the years been hampered by geographical disparities, financial burden, and social-cultural barriers making health care provision a challenge [11]. Having a strong health information system(HIS) has shown great potential in both developed and developing countries with regard to the achievement of health related MDG goals by ensuring presence of information useful for health monitoring, evaluation and improvement of healthcare service delivery[5]. A number of strategies have thus been undertaken over the years to improve the healthcare of the citizens starting with Kenya Health Policy Framework (KHPF) of 1994, first National Health Sector Strategic Plan(NHSSP-1) of 1999-2004 and second National Health Sector Strategic Plan-NHSSP-II(2005-2010). NHSSP-II proposed the need for an effective health information System that provides an integrated data collection and reporting tools, improved data flow mechanisms, Districts support in supervisions, improved feedback at all levels etc[8].

In addition, community health strategy was adopted in Kenya in 2006 to bring services to the household and community level [7]. Under this strategy, CHVs are required to collect health status data and account for services offered at house hold level which is later used for dialogue to make informed decisions and actions by relevant stakeholders at all levels to promote improvement in health status [10]. The use of manual reporting forms increases frequency of errors, high workload

at health facilities by the health workers leaving insufficient time for effective data compilation and reporting thereby contributing to a weak CBHIS and subsequently HIS [7].

The potential of mobile technology in enhancing CBHIs process flows, through an SMS-based reporting prototype was tested for (timeliness, cost, accuracy, removal of distance barrier, completeness) on community health data transmission, aggregation and analysis and feedback of key indicators to enhance the CBHIS process flows and ultimately community health strategy goal.

2. Objectives

The main objective of the research was to test the potential of open source mobile technology in improving community health strategy by enhancing the CBHIS process flow in low resource settings.

The specific objectives of the study were:

1. Improving timeliness,
2. Reduce transport costs
3. Improve accuracies
4. Reduce distance barrier
5. Improve completeness of submitted reports

Community Health Strategy Overview

Communities are the foundation of affordable, equitable and effective health care [7]. In this regard, the Kenya Essential Package for Health (KEPH) recommended in the second National Health Strategic Plan 2005(NHSSP II) was unveiled. This strategy laid out measures to be taken to ensure individuals and communities are empowered take active role in healthcare delivery. This would in turn improve community access to health care thus improving productivity, reduce poverty, hunger, child and maternal deaths and also improve education performance [7].

To help achieve the above, a sustainable LEVEL ONE SERVICES which was established is aimed at empowering households and communities take more active role in both preventive and promotive health care. It exists in CHUs and comprises of Community Health Volunteers (CHVs), Community Health Extension Workers (CHEWs) and Community Health Committees (CHCs). The CHVs are responsible for supporting the CHEWs in Level 1 and the communities on how to improve their health status. The CHEWs are mandated to provide health services at the community level while the CHCs support and facilitate community dialogues, health actions and mobilize resources.

Community Based Health Information System in Kenya

According to community health strategy, CBHIS refers to information required, gathered, analyzed and use by the community as well as other levels for planning, monitoring and decision making [7],[8]. The system collects the following types of information; demographic, nutrition, immunization, malaria, reproductive and child health, health status, environmental sanitation/water, school, social economic.

Effective implementation of CHS has seen the adoption of various monitoring and evaluation CBHIS tools which include: household register (MOH513), service delivery logbook (MOH 514), community health extension Worker Summary (MOH515), and community chalk board (MOH516) and community health worker referral tool(MOH 100) among others [7],[14].

The CHVs fill MOH513 biannually taking baseline health and demographic information of the households. They fill MOH514 monthly for all services offered during the month. They then submit their MOH514 to the CHEW for the CHEW to perform data quality checks, aggregation and

summarization of the data and submit to upper levels for uploading in district health information system (DHIS) and the chalkboard. According to a case study review of CBHIS in Kenya conducted in 2011, there is lack of consistency, coverage and accurate use of tools thus raising concerns on completeness and accuracy of the data. Monthly data collection coverage was reported at 24%, whereas monthly CHVs reporting rate at 57% (MOH, 2011). Whereas improved access to information confirms improved decision making at community level, untimely, incomplete reporting results into late decision making and subsequent late intervention towards prevention of certain outbreaks that could have otherwise been prevented earlier [3]

Challenges with MOH data collection tools, data quality and reporting rates have necessitated division of community health services to explore the possibility of ICT tools as potential complements to the realization of an effective CBHIS to make work processes more efficient. Mobile technology have also been recommended as effective through automated compilation and report generation to improve data quality through data accuracy, timeliness and completeness [3]. This is further supported by a report by [7] recommending a strong community data collection and monitoring systems to fully have a functional CHUs with capacity to assess, analyze, plan, implement and manage health related issues.

3. Methodology

The nature of this research was to identify the challenges faced by CHVs under the CHIS in using paper-based tools for data collection. In addition, through user involvement, to design and test an SMS-based prototype to enhance the data collection process flow to meet the above objectives. Thus the study adopted both qualitative and quantitative methods.A series of focused group discussionsand observations were carried out to understand CHIS current data collection process flow challenges.

The challenges were then grouped under thematic areas which gave the idea of the solution to build. The same techniques were used during prototype the design and pilot testingin subsequent iterative stages to makeprototype usable since the participants had a chance to state what they had concerning the system and also recommend for additional features as well as changes to be incorporated. Questionnaires were used to assess their perceptions on usability and usefulness of the system within the 3-Month period they had reported using it using the likert-scale. This helped to get individual perception of the system in regard to how it had improved their data reporting processes; data transmission, data aggregation and analysis.

3.1 General study area characteristics

The population included all the 25 Community Health Volunteers (CHVs) and the 2 Community Health Extension Workers (CHEWs) who are based at Kinamba Community Unit, MCUL Code 600953 attached to Ndindika Health Facility. The Unit is located in Kenya, Laikipia County, Nyahururu District, Ng'arua Division, Kinamba Location. The choice was made as it affects the objectives of this study and this group of people jointly helped with the system development as well as in data collection.In addition, the findings would help in informing ways to improve community process flow to the community health volunteers.

4. Technology Description

4.1 Designing the SMS-based health data reporting tool

The SMS-based reporting system designed to enhance CBHIS is based on FrontlineSMS open source framework. It enables rapid development of SMS-based applications with web interfaces for easy compilation and analysis. During the period of July-October 2014, the system was jointly

developed together with CHVs, CHCs and CHEWs through several iterations so as it adapts to suit the CBHIS MOH515 reporting tool and is customized to suit the local infrastructural and user requirements. A sim card was procured under Safaricom network, a local telecom service provider and the community unit provided a computer which acted as a server for the system and a modem for transmitting and receiving SMS messages from the CHVs.

To transmit a submission report, a structured SMS format was designed as follows:

Report IndicatorValue IndicatorValueIndicatorValueIndicatorValue where **Report** is the keyword specifying it's a report submission, **Indicator** to represent a given community health indicator as shown in Figure 1 and **Value** to represent the number of incidences reported in the given community.

Figure 1: Sample SMS to illustrate a transmission report

No financial or other incentives such as phones, airtime, and allowances were provided to the CHVs and CHEW for reporting purposes. All the 25 CHVs and 2 CHEWs possessed personal mobile phones with majority owning basic phones hence avoiding the expense of purchasing and maintain mobile phones for them.

4.2 Training and deployment

A full day training was conducted at the health facility where the 18 out of 25 CHVs, 8 CHCs and 1 CHEW assembled for the training on the use of the SMS-based reporting tool. At the time of the training, the CHVs were each required to bring along their own mobile phones and were each given a copy of the modified MOH515 form for pilot testing. An earlier situation analysis had been conducted at the community unit aimed at establishing type of mobile phone owned by the health workers, its availability and willingness to use it for transmitting community health data.

4.3 Data submission, correlation and summarization

All CHEWs are required to send a complete monthly report (MOH515) to sub-county health team and thereafter into the National Health Management System (NHMIS) by the set deadline. The CHVs are conversant with compilation of their individual monthly datasets thus relieving CHEW of their huge workload.

Letter	Sno	Indicator	Number
A	1	Number of House holds	
B	2	Total Population	
C	3	Total women 15-49 years	
D	4	Total children 0-6 months	
E	5	Total children under one year old	

Figure 2: A screenshot of Modified MOH515 form

After generation of values using the modified MOH515 as shown in figure 2, the CHVs send their datasets as an SMS according to the format provided in figure 1. The system captures the data and sends a confirmation SMS back to CHVs and also forwards an SMS to CHEW notifying them to review the information. Once reviewed, the records automatically become visible on the offline web system as shown.

A sample screenshot of SMS submissions in web module

5. Analysis

Since the study focused on development of a prototype and evaluating its impact in health data management from the user's perspective, quantitative and qualitative data analysis presented the best option for data analysis. Qualitative data analysis from focused group discussions and interviews was qualitatively analyzed with a view to identify emerging themes and categories arising from the data. Quantitative data analysis from the self-completion questionnaire by the community health volunteers was analyzed using Excel. The Median (Mdn),Mode and Inter-Quartile Range (IQR) were calculated from the Likert-Scale results. The research findings were then presented according to research objectives

6. Results

A total of 16 participants took part in the survey to test the usability and usefulness of the prototype for data collection, aggregation, and analysis of the CBHIS information flow. The findings indicate basic phone being the type of phone owned by majority as shown below.

Table 1: Type of phone used

Type of Phone used	Frequency	Percent count (%)
Basic Phone	13	81%
Feature Phone	0	0%
Smart Phone	3	19%

In evaluating the proposed prototype for data submission based on a 7-point likert scale and using median (Mdn) and inter-quartile range (IQR), it was necessary to assess users' ability to operate their phones without assistance. Majority of the participants indicated agreement with the statement of being able to operate their phones without seeking help (Mdn=6, IQR=1). This is possibly because majority of the respondents confirmed to using basic phones for communication (81%).

In addition, assessment of ease of use of SMS to submit data had majority of respondents expressing agreement as well as preference of submitting records via SMS. In regard to usability, the respondents expressed great satisfaction with the ease of use of the system (Mdn=6, IQR=1) and would recommend it to their fellow CHVs (Mdn=6, IQR=1).

Table 2: satisfaction results for the tested sample

Overall Satisfaction	Total(N=16)	Percentage
Strongly agree	8	50%
agree	8	50%

Further, the survey was used to test the usefulness of the prototype in regard to timeliness, completeness, cost and accuracy during data transmission, aggregation and analysis.

Timeliness

Timeliness is assessed as submission of the reports by an accepted deadline [1]. Under paper-based method, each CHW acknowledged using an average of 198.75 Minutes or 3 Hours and

18Minutes man-hours monthly to prepare individual summary report and village summary report thus making the manual aggregations more time consuming as shown in the figure 2. Further evidence can be seen by the respondents' agreement that use of SMS has enabled them save on time to undertake other roles as well as submit the records on time (Mdn=7, IQR=1). The CHEW confirmed to using over 3 days to prepare final summary report as not all individual reports are submitted by the stated deadline.

Further, the CHVs acknowledged using an average of 17 Minutes to prepare their Individual SMS for submission of their records.This is partly because they have to prepare their SMS in a particular format. Thus, SMS-based reporting helped save approximately 226 fewer hours of worker time per 2-month period translating to 1,356 hours saved annually which CHVs can use in other roles. These results showed a potential of substantial reduction of time taken to generate final Monthly report through SMS transmission as opposed to the manual process.

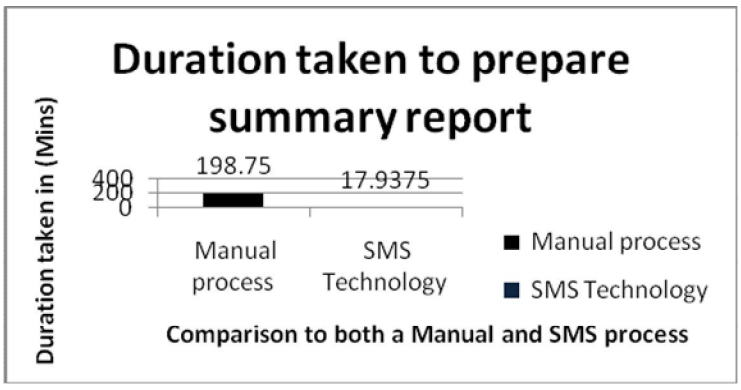

Figure3: Duration taken to prepare summary report.

Cost

On average, it was found that the 25 CHVs spend Ksh1,875 per month and Ksh22,500 per year as transport cost to take the data to the health facility considering no allowance is offered for bringing the summary report to the health facility not to mention the huge printing costs incurred for the paper forms.

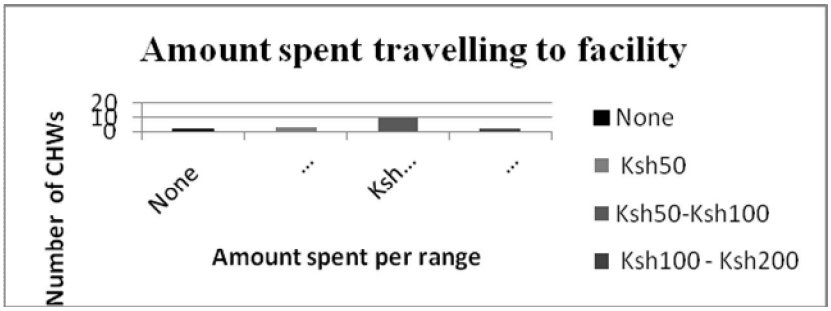

Figure 4: Range of Amount Spent Travelling to Facility

The introduction of SMS-based data transmission where each CHV spends Ksh 1 per SMS equates to an average annual Ksh 720 to transmit the same data from their homes hence leading to 97% cost savings for the CHVs which in turn can be used to feed their families.

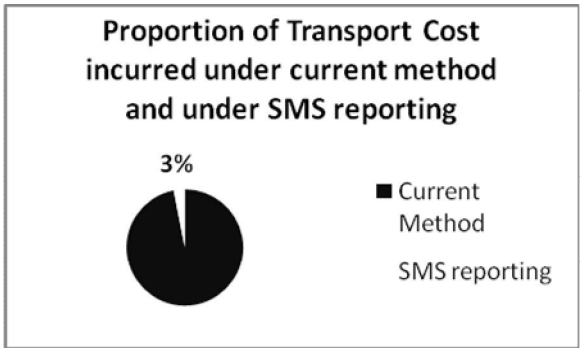

Figure 5: Proportion of Transport Cost incurred under current method and under SMS reporting

Distance

The studies found that majority of CHVs reside more than 2.5Kms away from the health facility and this distance barrier affects the number reports submitted to the health facility. The above might be a reason as to why majority of them were in agreement towards support for the use of SMS to submit their data as opposed to physical submission which would require them to travel (Mdn=6, IQR=1).

Accuracy

Although it wasn't possible to obtain the source documents that are used for aggregation to countercheck the individual MOH515 reports generated by the CHVs with the final report manually aggregated, a review of past final reports for over six months in the Community unit showed similar values being repeated in most reports indicating possibilities of incorrect values being reported. This is further evidenced by high number of respondents strongly agreeing (N=7, 44%), a larger proportion agreeing (N=8, 50%) to possibility of making arithmetic errors while doing aggregation (Mdn=6, IQR=1) as indicated by the manual aggregation picture shown below.

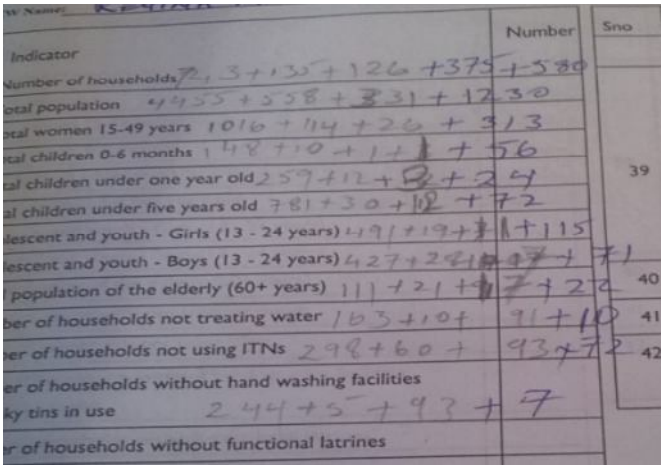

Figure 6: A picture showing manual aggregation

Completeness

A review of past summary documents normally submitted to the district headquarters showed the total number range of CHVs whose reports were used to generate the final report as shown in table 6. The month of March and April witnessed 100% reporting partly due the moral monthly allowances offered but subsequent months after confirmed allowance withdrawal reporting rates

reduce. The proposed prototype was used in reporting in August and September and this resulted to a 16% increase in reporting by the CHVs for the 3-month period. This was also confirmed by an interview with the CHEW who cited an increment in the number of CHVs submitting their records within the stated deadline and thus a complete report being submitted.

These results are further confirmed by the responses that use of SMS has enabled them submit their records on time (Mdn=7, IQR=1). These findings are further supported by a report on CBHIS which found monthly CHVs reporting rates at 57% [6].

Table 3: Total Monthly Reporting for the 10 villages based on Individual CHW reports (* estimated range)

Month	Total Reported	Reporting rates (Based on CHVs)
March	25 CHVs	100%
April	25 CHVs	100%
May	10 villages(10-25CHVs) *	40%-100% *
June	8 Villages(8-20CHVs) *	32%-80% *
July	8 Villages(8-20CHVs) *	32%-80% *
Aug	23 CHVs	92%
Sep	24 CHVs	96%
Oct	24 CHVs	96%

7. Business Benefits

The use of manual reporting forms increases frequency of errors, high workload at health facilities by health workers leaving insufficient time for effective data compilation and reporting thereby contributing to a weak CBHIS and subsequently HMIS [7].

To begin with, the use of SMS to transmit the data may greatly reduce transport costs incurred by the CHVs to submit their monthly reports as some live far away from the health facilities. Thus at a cost of Ksh 1 per SMS, the CHVs are able to submit the same report and can use the saved amount to feed for their families. Furthermore, the automatic submission, aggregation of data which is remotely submitted by the prototype greatly saved on time which is initially wasted at the health facility as all the individual reports have to be collected before aggregation can take place as well time spent travelling from homesteads to take the manual reports to the health facility. Data aggregation and summary report generation in the proposed prototype has been eased as the datais directly submitted into the system as an SMS, automatically aggregated; therefore human aggregation errors can be greatly reduced and increase data accuracy. Thus text messaging has been as a vital tool for CHVs to report data as it has been found to improve accuracy, reduce time and costs

Our experience with piloting this self-sustaining SMS-based reporting system and findings by [13] and [4] demonstrate that remote submission through a similar system can greatly improve timeliness by minimizing the time lag from when data is submitted to when it's available for use. The potential of SMS-based reporting to enhance CBHIS can too be confirmed by [9] under the SMS-based alert system (RapidSMS-MCH) in Rwanda, mTrac of Uganda [6]. Secondly, the project has demonstrated how SMS-based reporting can eliminate distance barriers and transport cost incurred which affects completeness and timeliness of final report submission.

Automatic collection, aggregation and analysis of data demonstrate how SMS-based reporting may help curb inaccuracies in computations thus making data reliable for quicker decision making. These findings are further confirmed by [6] in mTrac project of Uganda where SMS reporting, automatic aggregation, analysis of the data has led to quicker decision making.

However, maintenance of the high reporting rates among the CHVs may be hampered by ongoing challenges both usability and errors. Despite the use of mobile phones for SMS based

reporting helping overcome many challenges associated with data collection, making the CHVs stick to the SMS format when many indicators are being reported: Omissions, Letter confusion-Capital I and L in basic Phones, invalid spaces, characters etc has proven to be a challenge. In addition limited GSM network connection at times was also seen as a challenge towards making the system achieve its objectives.

8. Conclusion

Overall, the research aim was to show the potential of mobile technology in enhancingCHIS process flow in low resource settingsif CHVs are empowered with mobile phones. However, the choice of phones should consider the context of use: electricity access and cost, familiarity etc.In addition, the research showed that technology offers an alternative approach that's cheaper to exclusive paper-based tools. Moreover, the research showedthe potential of rapid user acceptance to anymHealth systemif it matches the user and infrastructural requirements of the given context and there is user involvement. Whereas data collection processes can be improved, the use of health information for community action requires the CHVs appreciate data ownership and eliminate perception that their role ends when they submit their data to the health facility.

Usability enhancement and error handling should be researched more to make it easy for CHVs in appreciating the role of mobile technology through use of forms(simple applications). This would be possible through adoption of low-cost smart phones which would greatly improve usability and reduce error possibility.The prototype should be piloted in several community health units with similar settings around the country and evaluate them to inform policy formulation. This will inform the minimum structures of a sustainable mobile model that can facilitate and enhance data-demand and information use at the community health level as opposed to the current paper model as well as how data can be integrated into the National Health Management System.

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