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Community Health Volunteers' Decision Support System Project

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This report presents the key findings of the end-of-project assessment of households and community health volunteers, conducted in 2017 in the Kamukunji and Embakasi sub-counties of Nairobi, Kenya, for a Community Health Volunteers' Decision Support System (CHV DSS) intervention project. The report was prepared by the African Population and Health Research Center (APHRC). The end-line survey was implemented by APHRC. Implementation of the CHV DSS project is a joint collaboration among several partners, including APHRC, the City County of Nairobi, sub-county health management teams (Kamukunji and Embakasi), and community health volunteers. The opinions expressed in this report are those of the authors and do not necessarily reflect the views of the donor organization, the County Innovation Challenge Fund for Kenya.

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None declared

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List of Abbreviations

ANC	Antenatal care
APHRC	African Population and Health Research Center
CHA	Community health assistant
CHV	Community health volunteer
CU	Community unit
DSS	Decision support system
EBF	Exclusive breastfeeding
e-Health	Electronic health
FP	Family Planning
ESRC	Ethics and scientific review committee
FGD	Focus group discussion
FI	Field interviewer
HCW	Health care workers
ICT	Information and communications technology
IDI	In-depth Interview
IUCD	Intrauterine contraceptive device
KCSE	Kenya Certificate of Secondary Education
KII	Key informant interview
m-Health	Mobile health
MNH	Maternal and newborn health
MOH	Ministry of Health
mPAMANECH	Mobile partnership for maternal, newborn and child health
PNC	Postnatal care
SBA	Skilled birth attendant
SCHMT	Sub-county health management team
SSA	Sub-Saharan Africa
SDG	Sustainable development goals
SUS	System usability scale

Executive Summary

This report summarizes the evaluation of an intervention project that developed and tested a decision support mobile health (mHealth) application. The application was developed as an integrated data capture tool running as a mobile application with selected reporting forms for community health volunteers (CHVs) in Kenya and connected to health facilities. The system is an attempt to improve CHV decision-making and referral mechanisms for mothers and newborns. Following a year of implementation, we explored the experiences of CHVs, health workers and members of sub-county health management teams (SCHMT) with respect to improving maternal and newborn health (MNH) outcomes in the urban slums of Kamukunji sub-county in Nairobi, Kenya.

Data were collected in December 2017 through household and CHV surveys, in-depth (health workers) and key informant interviews (sub-county health managers) and focus group discussions (CHVs). Qualitative data was analyzed using the content analysis method, while quantitative data was obtained using descriptive analyses involving obtaining frequencies and percentages for different categories and stratifying the results by study site. Overall, there were declines in pregnant women attending at least four antenatal care visits (from 41% to 28%) as well as the proportion of women with a skilled attendant at delivery (93% to 87%). The reductions were slightly more pronounced in Kamukunji (intervention) than in Embakasi (control). On the other hand, CHVs' knowledge showed an increase, specifically on the identification of at least four neonatal danger signs (79% to 91%) and identification of pregnancy danger signs (91% to 100%). The increase in knowledge was slightly more significant in Kamukunji (91% to 100%) than in Embakasi (98% to 100%).

On the application, the usability scores among CHVs were high when the application was introduced but decreased at end-line. The decrease is attributable to lack of feedback from the health facilities to the CHVs which saw the introduction of paper to prove completion of the referral loop, which was meant to have been a role of the healthcare workers (HCWs), through the system. The inverse is seen with the HCWs, as the health facilities' users were not constant through the life of the project. The CHVs found the application easy to use and learn, while the HCWs found the web application well-integrated. Regarding users and health managers' perceptions towards the system, three main themes emerged: 1) variations in use, 2) barriers to use, and 3) recommendations to improve use. Three sub-themes under barriers to use were socio-political environment, attitudes and behaviour, and issues related to the system. A prolonged nationwide health workers' strike, the contentious presidential election in the year of implementation characterised by uncertainty and bouts of insecurity that interrupted work, interrupted electricity supply, and a lack of basic electric fixtures were major barriers to use. The private facility and some CHVs used the system more than health workers at the public facilities. Participants suggested strategies to improve usage: First, integrate the system with others in use and make it available on users' regular phones. Second, provide extra financial motivation for users, as well as performance-based remuneration. The findings reveal the necessity in considering the information and communication technology (ICT) readiness of users as well as the political and sociocultural environment, and emphasize the importance of users in the development of such solutions.

The study demonstrates the feasibility and acceptability of this type of research in a previously under-researched sub-population. It serves as a basis for future work that could highlight opportunities to respond to the persistent challenges surrounding m-Health implementation in low-resource settings.

As more healthcare delivery models are developed, harnessing the potential of digital technologies to strengthen health systems is critical, as this provides the backbone for innovation. Furthermore, ensuring ICT readiness of users, and their working environments are important for successful implementation. Lastly, integration of new solutions into existing ones has the potential to improve use.

While our study provides a rich context to m-Health implementation in this setting (in Nairobi slums), we only elicit the perspectives of individuals resident and/or working in this community. Furthermore, the short implementation period needs to be taken into account, especially in relation to the socio-political environment prevalent during the period.

The report is organized into the following sections: Introduction, Methodology, Key findings, Discussion, Conclusions, and Recommendations.

1

Introduction

Improving maternal, neonatal and child survival remain major aspirations for many countries in sub-Saharan Africa (SSA) and South Asia, which regions together contribute to over 90% of the global deaths due to maternal and child-related deaths [1-3]. The Sustainable Development Goals (SDGs) include a goal on attainment of health for all [4, 5]. Most maternal and newborn deaths are due to causes directly related to pregnancy and childbirth. Most of these causes are preventable with existing cost-effective interventions [2, 3]. Despite the existence of and knowledge about simple strategies and techniques to reduce maternal and newborn deaths, these interventions are not up to scale in Kenya as elsewhere in SSA due to the inadequacy of health care facilities, trained personnel, information, poor referral systems and pervasive poverty. As a result, Kenya still experiences high maternal and newborn mortality rates at 362/100,000 and 22 deaths per 1000 live births, [6, 7], respectively. Neonatal deaths (that occur from birth to one month of age) account for about 60% of all infant deaths (from one month to one year of age) in Kenya [7].

Evidence suggests that mobile and electronic technologies have a lot of potential in delivering vital health care interventions across the maternal and child health continuum of care [8]. This is particularly important in low-resource settings. Several projects reported improvements in services rendered by CHVs and the related health outcomes for communities. In SSA, most of the interventions demonstrated improvements in the CHVs' delivery of maternal, newborn, and child health services, among others [9].

Kenya, known as the 'Silicon Savannah', is an ICT giant in East Africa [10]. Globally, Kenya has one of the highest mobile penetration rates (88%) and internet access through mobile phones (99%) [11-13]--two of every three Kenyans has internet access [13]. The growth in ICT is due to significant investments from the public and private sector in infrastructure (for instance, national fiberoptics) and mobile device use [14-16]; ultimately enhancing the country's acceptance of ICT [10]. Numerous digital innovations such as M-pesa successfully used the country's mobile phone penetration in the provision of financial solutions to Kenyans of all walks of life. However, the health sector has not yet unlocked the full potential of technology. Numerous e-health innovations were developed and implemented in the country but very few, if any, have gone to scale due to numerous challenges. There is need to identify and address the gaps in order to have clear directions on where to focus investment, in a coordinated manner, to benefit from this 'quiet revolution', otherwise Kenya faces the risk of wasted resources and a digital health divide in health care.

Policy environment

A commendable step is the country's initiatives in developing policies and strategies to facilitate the growth of ICT solutions in health. The Ministry of Health (MOH) recognized and prioritized ICT as a driver to the realization of SDGs and Vision 2030, and as the conduit to the provision of the highest quality care to its people, as enshrined in the constitution (2010). This is demonstrated by the launch of Kenya's first national e-health Strategy (2011-2017) [17], which seeks to strengthen the health system and subsequently extend equity in health care to poor and marginalized populations. This strategy is to be

delivered through five key areas: telemedicine; electronic health records (health information systems); information for citizens; m-Health (mobile technologies in health); and eLearning or distance education for health professionals. One of the policy objectives in the Kenya Health Policy (2014-2030) aims to plan, design and install ICT infrastructure and software for the management and delivery of essential healthcare. Finally, the National e-Health Policy (2016-2030) strives to "create an enabling environment for the sustainable adoption, implementation and efficient use of e-Health products and services at all levels of healthcare delivery the country".

Building on lessons learned across SSA, and in a bid to improve the health management information system, an innovative m-Health application was developed as an integrated data capture tool that runs as a mobile application with selected reporting forms for CHVs in Kenya [18]. It operates in an interconnected network of CHVs and health facilities within a defined local system and is designed to replace the numerous paper-based forms that do not allow integration of patient data from the community to the health facility and back for better referral and management of patients. This system both improved the reporting abilities of CHVs, as it is less cumbersome than the paper-based system, and enhanced data quality, as it has a function that limits saving data until all necessary fields are filled in [19]. In addition, the community health assistants (CHA) can remotely access CHV data without waiting for end-of-the-month summaries. The desire to improve the functionality of the system to include a decision support function provided the basis of this project. CHV views were included throughout its development and implementation. The system uses MOH-approved tools. The decision support system was developed using open source tools.

Objectives

This report is based on end-line data collected in October-December 2017 for the CHV decision support system (DSS) project. It presents lessons learned as well as the changes in key performance indicators against baseline values. Where possible, the data is further compared with the results obtained at baseline (December 2016). The study's aim was to measure the progress towards accomplishing the development and validation of a decision-support algorithm within a m-Health application in improving MNH outcomes in urban slums in Kamukunji sub-county in Nairobi, Kenya. The project sought to assess the added value of using a CHV decision-support module of mobile partnership for maternal, newborn and child health (mPAMANECH) in reducing prenatal and postnatal maternal complications and newborn deaths.

The specific objectives of the research were to:

1) Assess the feasibility of using a decision-support module of mPAMANECH in an urban poor setting (slum);

2) Assess the acceptability of using a decision-support module of mPAMANECH by CHVs working in slums; and

3) Determine the effect of the intervention on use of MNH services, and reduction of MNH complications and deaths in a slum setting.

2

Methodology

a. Study setting and design

Kamukunji sub-county served as the intervention site and Embakasi sub-county was the control site. The intervention and control sites are comparable as they cover informal settlements in the two sub-counties, which – like other slums – are characterized by poverty, poor coverage of social services, and poor health outcomes. The project worked with five community units (CUs) and five health facilities from which a group of 50 CHVs served as the intervention group in Kamukunji, and three CUs and three health facilities from which a group of 30 CHVs served as the control in Embakasi sub-county. The CUs and health facilities in the control group are geographically distant from the intervention site to limit contamination.

To determine the effect of the decision support system, a quasi-experimental design with pre-and- post assessments to measure the impact, if any, on the MNH services and selected health indicators was used. To measure feasibility and acceptability, the end-line survey employed a mixed method approach combining both qualitative and quantitative data collection methods. Qualitative assessments were conducted of CHVs' and CHAs' current work experiences during the past one year with the introduction of the mobile-based system (Kamukunji) and the paper-based system (Embakasi). The assessment covered ease of use, challenges experienced, and opportunities for improvement.

b. Sampling

The CUs in the intervention and control groups were purposively selected based on discussions with the sub-county community health strategy coordinator for Kamukunji and Embakasi [18]. We selected CUs with the worst health indicators, including those serving informal settlements, and with more likelihood to benefit from the intervention.

The survey targeted households with women of reproductive age (12-49 years) in the informal settlements of Kamukunji and Embakasi. To understand their health-seeking behaviors, the population-based survey obtained data from pregnant women and those with children under one year of age. Mothers with children under one year were chosen because they would have had a recent experience with childbirth. The households registered by the CHVs during implementation of the CHV DSS project were selected. Health care workers in the selected health facilities and members of the sub-county Health Management teams were purposively selected and interviewed. Participants in the qualitative data collection, that is, focus group discussions (FGDs) and in-depth interviews (IDIs) were conducted among the direct project beneficiaries and CHVs, and key informant interviews (KIIs) with key actors (SCHMTs, health providers, and CHVs). These participants were purposively selected to represent the different stakeholders as well as different health services. Some respondents were identified based on their position in the role in the project.

c. Data collection procedures

The qualitative and quantitative tools were developed in English and translated to Swahili. Back-translation was done to ensure that meaning was not lost. Three survey tools were used to capture quantitative information: a questionnaire for women of reproductive age, a CHV questionnaire, and a health facility questionnaire. The translated quantitative tools were programmed in Survey CTO software, which was uploaded to tablets. The electronic data collection tools were administered by trained data collectors who captured the information through face-to-face interviews with respondents. Each interview took about 45-60 minutes. Women provided information on background characteristics (such as age, education level, marital status, and source of livelihood), family planning and health-seeking behavior including vaccination. In addition to background information, the CHVs provided information on the households allocated to them, community services they provide, and data documentation. CHVs from Kamukunji provided additional information on the acceptability and usability of the mobile application.

The qualitative data were collected through FGDs with purposively selected CHVs and women who met the inclusion criteria, whereas IDIs were only conducted with selected CHVs. FGDs and IDIs were conducted by a moderator in Swahili, assisted by a note taker. Key informant interviews (KIIs) were conducted in English with health care workers, CHAs and sub-county health management teams. The discussion notes were supplemented by observational notes for each interview. Each interview took about 60 minutes. The interviews were tape-recorded and held in private spaces free of attentive eyes, eavesdroppers, threat of sanctions, and pressure from non-participants. A total of 10 IDIs, 20 KIIs, 12 FGDs (six with CHVs, six with women of reproductive age) were conducted.

d. Training for the data collectors

A transparent recruitment process was done to select interviewers based on education level, prior experience working on similar surveys, place of residence and proficiency in English and Swahili, both orally and in written form. The minimum education qualification for a quantitative data collector was a C+ in the Kenya Certificate of Secondary Education (KCSE) while qualitative data collectors were graduates in relevant fields including Public Health and with experience in qualitative research, ability to relate to the target group, and ability to speak the survey language.

A total of 31 interviewers were shortlisted and underwent a one-week training covering project objectives, ethics in research and a comprehensive review of the data collection tools. The training consisted of a detailed, question-by-question explanation of the questionnaires/interview guides, demonstration of interviewing techniques through role-plays, group discussions, procedures for seeking informed consent, a collection of data using tablets, troubleshooting, and field logistics. Piloting of the instruments was conducted in Shauri Moyo in Kamukunji sub-county to ensure trainees grasped the questions and that the data collection tools captured as expected.

Six team leaders were selected based on their experience in the conduct of surveys and their leadership abilities. The team leaders received additional training in the management of data collection, team dynamics, survey planning and logistics, observing interviews, and spot-checking for data quality. Each team leader was assigned a team of four to five field interviewers (FIs). They also assisted in revising the tools based on outcomes of the pilot study.

e. Data management

To ensure validity, validation checks, constraints or skips were embedded in the Open Data Kit (ODK) software during development of the quantitative tool. The electronic form was programmed to not save forms with missing data and implausible, out-of-range values. The quality control team tested it to ensure consistency and question flow before the tool's implementation. To further ensure data quality, during fieldwork, each team leader conducted regular spot checks and sit-ins to 10% of each FI's work and verified authenticity on 100% of the FIs' daily output before synchronizing the collected data with a master database in the APHRC head office. Furthermore, the research team held weekly meetings with the field team, addressing

any inconsistencies or errors in the data with the responsible interviewer. An automated routine to check on the data completeness, correctness and consistency ran on 100% of the collected data. Data was exported to STATA for advanced cleaning and analysis.

Qualitative data was tape-recorded and transcribed verbatim. Transcribed files were saved in Microsoft Word.

f. Ethical considerations

Amref Health Africa's Ethics and Scientific Review Committee (AMREF ESRC), which is accredited by the Government of Kenya, granted ethical approval for the end-line survey. The study protocol number is P279/2016. All participants recruited into the study signed an informed consent form administered in either Swahili or English (for key informants) after a briefing on study aims, procedures, benefits and potential harms, as well as their voluntary participation. Moreover, the contact detail of at least one of the investigators, as well as the AMREF ESRC, were made available if participants had specific concerns.

g. Analyses

Quantitative

Descriptive analysis of quantitative data involved obtaining frequencies and percentages for different categories and stratifying the results

Table 1: Status of outcome indicators

The domain of inquiry: Assess the feasibility and acceptability of using a decision-support module of mPAMANECH		
Status	**Initial Indicator**	**Revised Indicator**
Revised	Proportion of pregnant women referred for antenatal care (ANC) by CHVs	Proportion of pregnant women referred by CHVs for ANC who received ANC service
Revised	Proportion of mothers referred for PNC by CHVs	Proportion of mothers referred by CHVs for PNC and receive PNC service
Revised	Percentage time for which the system is down on a monthly basis	Proportion of CHVs reporting challenges with the functionality of the app
Retained	Proportion of CHVs able to identify at least four danger signs among neonates	
Retained	Proportion of CHVs able to identify at least two post-partum complications	
Removed	Number of CHVs effectively using the decision support tool	
Removed	Proportion of CHVs able to identify high-risk pregnancies that require early referral at the onset of labor	
Removed	Percentage of correct referral decisions by CHVs for post-partum mothers with complications	
Removed	Percentage of correct referral decisions by CHVs for neonates with danger signs	
Domain of inquiry: Determine the decision-support platform's effect on use of MNH services and MNH complications and deaths		
Status	**Initial Indicator**	**Revised Indicator**
Revised	Proportion of all mothers attending at least two post-natal care (PNC)	Proportion of all mothers (with babies under one year) attending at least 2 PNCs
Revised	Proportion of deliveries assisted by trained personnel	Proportion of women (with babies under one year) whose last delivery assisted by a skilled birth attendant
Revised	Proportion of women referred for post-partum family planning	Proportion of women referred for post-partum family planning and received the service
Revised	Proportion of low birth weight newborns referred	Percentage of low birth weight newborns (aged 0-28 days) referred by CHVs and receive services
Revised	Proportion of women lost during follow up	Percentage of mother's loss to follow up tracked
Revised	Proportion of newborns lost during follow up	Percentage of newborns loss to follow up tracked
Retained	Proportion of women attending at least four ANCs	
Retained	Percentage of women who accessed first ANC within the first trimester	
Removed	Proportion of newborns with at least one danger sign referred by CHVs	

by study site. In the process of strengthening the monitoring and evaluation of key outcome indicators, certain changes were made during implementation. Table 1, summarizes the changes made to the outcome indicators for specific project objectives. The outcomes considered were mother's healthcare-seeking behaviors and CHVs' ability to identify danger signs in pregnant, neonates and postpartum women, among others.

To measure feasibility and acceptability, all CHVs in the intervention site were assessed, in addition to an audit of the functionality of the system. Usability and acceptability were determined using the system usability scale (SUS) [20], which is composed of 10 statements (five negative and five positive). Each statement has a five-point scale ranging from Strongly Disagree to Strongly Agree. The response rating scores are as follows: Strongly Disagree=1, Disagree=2, Neutral=3, Agree=4 and Strongly Agree=5. The calculation of the SUS score has been described elsewhere https://bit.ly/2BvkF6m. The average SUS score of all SUS studies lies around 68. To determine the absolute usability associated with any individual SUS score, an eleventh question is asked in the SUS tool. However, instead of following the SUS format, the eleventh question uses a seven-point, adjective-anchored Likert scale with numerical equivalents of 1 through 7 assigned to the adjectives from Worst Imaginable to Best Imaginable. The adjective rating scale statement was added at the bottom of the same page as the SUS and was filled out immediately after the SUS ratings. The SUS with the added adjective scale was administered to 39 CHVs in the intervention site.

The CHV performance was determined by first identifying the total number of months that a CHV reached the project target (e.g. reaching a target of 15 per month, making it 45 per quarter for Quarter 5 and Quarter 6, and reaching a target of 8 for Quarter 7). Afterwards, the total number of months that a CHV reached the target was divided by the total number of months that the intervention was rolled out (9 months) multiplied by 100 percent to get a performance percentage. Finally, performance percentages were grouped and categorized into the scale below (Table 2). The scale is from four (best performance) to one (worst performance).

Table 2: CHV performance categories

Best Performance	Above Average Performance	Below Average Performance	Worst Performance
4 (100%-76%)	3 (75%-51%)	2 (50%-26%)	1 (25%-0%)

Qualitative

In order to describe and interpret the participants' experiences, views, and perceptions, audio-recorded discussions conducted in Swahili were translated to English and together with the interviews conducted in English transcribed, by an experienced transcriber, into Word files and imported into NVIVO software for coding and analysis. The transcribed discussions and interviews were coded using a preliminary coding scheme developed based on themes from the discussion and interview guides. This was followed by manual content analysis to describe and interpret the experiences of the CHVs, CHAs, health workers and health managers. Open coding was followed by scrutiny of each code resulting in refinement of the coding scheme. The resultant codes were organized under key emerging sub-themes from which themes were obtained. Findings from the CHVs were triangulated with IDI data from health workers and CHA and KII data from the community strategy coordinators for Embakasi South and Kamukunji sub-counties. Under each theme, the unit of analysis was the specific text about the CHVs' responses in relation to a particular subject. The discussion notes were further supported by observational notes made during field visits.

Table 3: Group composition and discussion guide for the qualitative interviews

INTERVIEW TYPE	NUMBER OF PARTICIPANTS		DETAILS
	Kamukunji	Embakasi	
FGDs			Experiences with health services including access and quality of care
Women (Pregnant and with children less than 12 months)	30	24	
CHVs	27 (3 male)	14 (2 male)	Data collection experiences (electronic versus manual) and role in the provision of community health services
IDIs			
CHVs	5 (1 male)	5 (1 male)	
KIIs	11 (4 male)	9 (4 male)	Access to and quality of and data collection experiences (electronic versus manual)
Total participants	**73**	**62**	

3

Key Findings

This section presents both quantitative and qualitative findings. In addition to the sociodemographic characteristics of women and CHVs, the quantitative findings compare baseline and end-line results, where possible, for both Kamukunji and Embakasi. The quantitative results are presented by domain as described above.

3.1 Characteristics of community health volunteers

3.1.1 Selected socio-demographic characteristics

Table 4 shows the general characteristics of the CHVs (N=63 CHVs; 39 from Kamukunji; and 24 from Embakasi) who participated in the quantitative interviews. The average age of CHVs was 43; the youngest was 25 and the oldest was 68. About 64% had secondary school as the highest level of education. The majority served as CHVs for more than five years.

Table 4: Selected socio-demographic characteristics of CHVs

	Kamukunji		Embakasi		Total	
	%	n	%	n	%	n
The highest level of education						
Primary school	25.6	10	29.2	7	27	17
Secondary school	59	23	70.8	17	**63.5**	40
College (certificate, Diploma)	15.4	6	0	0	9.5	6
Years served in the community						
1-2 years	5.1	2	12.5	3	7.9	5
2-4 years	7.7	3	33.3	8	23.8	15
More than 5 years	74.4	29	58.3	14	**68.3**	4

3.1.2. CHV data documentation methods

The most common method of data collection in Kamukunji was electronically using mobile or electronic devices (80%) and in Embakasi manually using MOH registers (75%). Collectively, nearly 68% of the CHVs were satisfied with the current method of data collection (Table 4). More than 90% of CHVs in Kamukunji reported that an electronic/mobile data capture system made their work easier, shortened the time taken in households, assisted in the correct identification of danger signs, increased timely referrals and reduced misdiagnosis at the community level.

Table 5: CHV data documentation methods

	Kamukunji		Embakasi		Total	
	%	n	%	n	%	n
Manually using MOH registers	7.7	3	**75**	18	33.3	21
Electronically using mobile or electronic devices	**79.5**	31	0	0	49.2	31
Others	12.5	5	25	6	17.5	11
Satisfaction with the current method of data collection						
Yes	87.2	34	33.3	8	**66.7**	42
No	12.8	5	66.7	16	33.3	21

3.2. Characteristics of household population and respondents

3.2.1 Selected socio-demographic characteristics of women

A total of 679 women (342 in Kamukunji, 337 in Embakasi); 407 mother-infant pairs and 273 pregnant women, with one pregnant woman having a child less than 12 months old, were interviewed. Almost all (98%) women attended school, with 45% completing primary school level. About 88% were in a union (married or living together) and only 28.6% had some form of livelihood (either self-employed, informal, or formal employment). Christianity was the predominant religion (86.8%) (Table 6).

Table 6: Selected socio-demographic characteristics of the women per site

	Kamukunji		Embakasi		Total	
	n	%	n	%	n	%
Currently pregnant						
Yes	151	44.2	122	36.2	273	40.2
No	191	55.8	215	63.2	406	59.8
Marital status						
Currently married	109	31.9	109	32.3	218	32.1
Living together	175	51.2	203	60.2	378	55.7
Separated	20	5.8	4	1.2	24	3.5
Divorced	3	0.9	1	0.3	4	0.6
Widowed	6	1.8	1	0.3	7	1
Never married	29	8.5	19	5.6	48	7.8
School attendance						
Yes	327	95.6	335	99.4	662	97.5
No	15	4.4	2	0.6	17	2.5
Highest level of education						
Preschool	0	0	1	0.3	1	0.1
Primary school	176	51.5	130	38.6	306	45.1
Secondary	123	36	166	49.3	289	42.6
College (certificate, diploma)	20	5.8	32	9.5	52	7.7
Undergraduate	1	0.3	3	0.9	4	0.6
Postgraduate (masters/PhD)	1	0.3	0	0	1	0.1
Other (specify)	6	1.8	3	0.9	9	1.3
Didn't respond	15	4.4	2	0.6	17	2.5
Do you have any children?						
Yes	290	84.8	290	86.1	580	85.4
No	52	15.2	47	13.9	99	14.6
Religion						
Catholics	58	17	91	27.0	149	21.9
Protestants	212	62.0	229	68.0	441	64.9
Muslims	69	20.2	11	3.3	80	11.8
No religion	3	0.9	1	0.3	4	0.6
Other	0	0.0	5	1.5	5	0.7
Main source of livelihood						
Self-employed	56	16.4	53	15.7	109	16.1
Employed: casual	40	11.7	16	4.7	56	8.2
Employed: salaried/formal	11	3.2	18	5.3	29	4.3
Unemployed	231	67.5	244	72.4	475	70
Student	4	1.2	5	1.5	9	1.3
Other	0	0	1	0.3	1	0.1

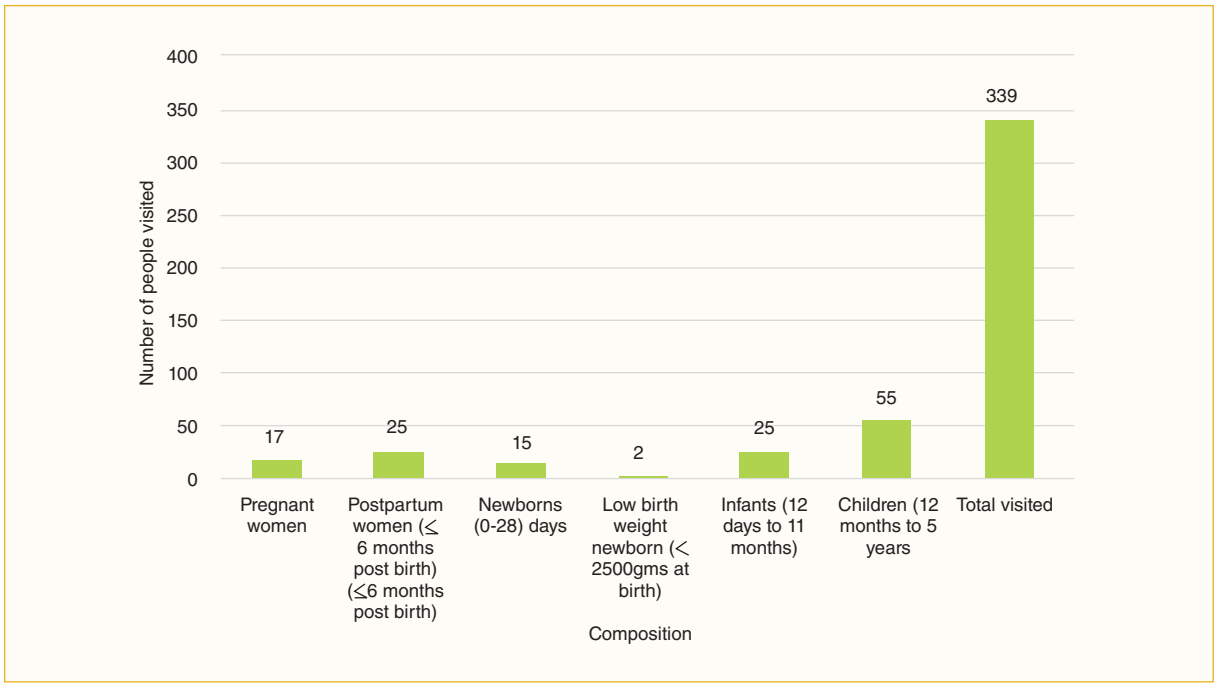
3.3. Feasibility and acceptability of the system

This section responds to objectives: (1) assessing the feasibility and (2) acceptability of using a decision-support module of mPAMANECH in an urban poor setting. In this section, we present findings from the exploration of the experiences of CHVs, health workers, and sub-county health management teams following the implementation of the system.

3.3.1 Composition of households allocated to CHVs

CHVs are allocated an average number of 90 households, with a minimum of 15 and a maximum of 300 households, median 72. There are 30 pregnant women in the allocated households; nine are categorized as high-risk pregnancies. In the last month prior to the survey, CHVs visited a total of 339 households comprising women of reproductive age, newborns, infants, and children. Figure 1 specifically highlights the maximum number of households visited with pregnant women, postpartum mothers and newborns.

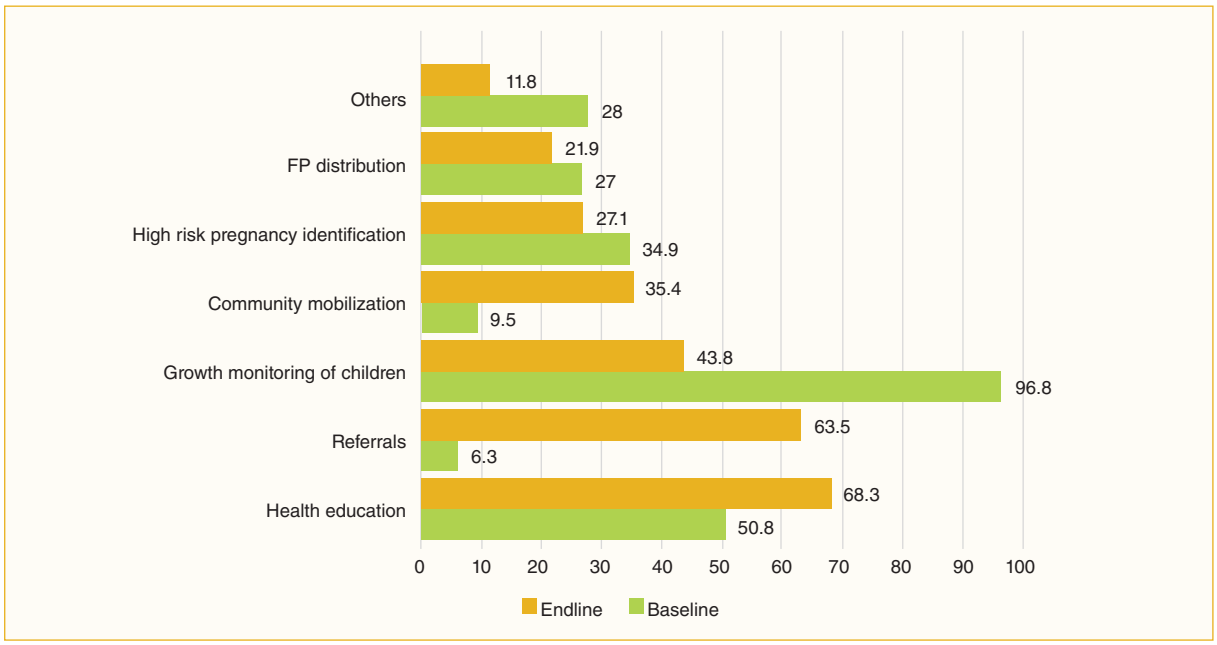
Figure 1: Composition of visited households in the month prior to the survey



3.3.2 CHV self-reported roles

In Kamukunji, the most mentioned key CHV roles at end-line were growth monitoring (97.4%) and health education on ANC (76.9%), proper nutrition (71.8%), danger signs in pregnancy (66.7%), danger signs in newborns (56.4%), PNC for mother (53.8%) and health facility-based delivery (51.3%). The proportion of CHVs who mentioned referral as a role dropped from 57.4% at baseline to 5.1% at end-line. Figure 2 compares the proportion of CHV roles mentioned at baseline with end-line results in both sites. Generally, the mention of health education of danger signs increased from baseline, with a noticeable 25% increase in the mention of health education on newborn danger signs as a role.

Figure 2: Community Health Volunteers self-reported roles in the community



There was a substantial decrease in the number of CHVs mentioning referrals as their role from baseline (63.5%) to end-line (6.3 %) in both sites. However, the average number of women referred by CHVs increased by 2.5 from 1.6 at baseline to 4.1 in end-line as reported by CHVs (Table 7). Postpartum family planning was not measured at baseline.

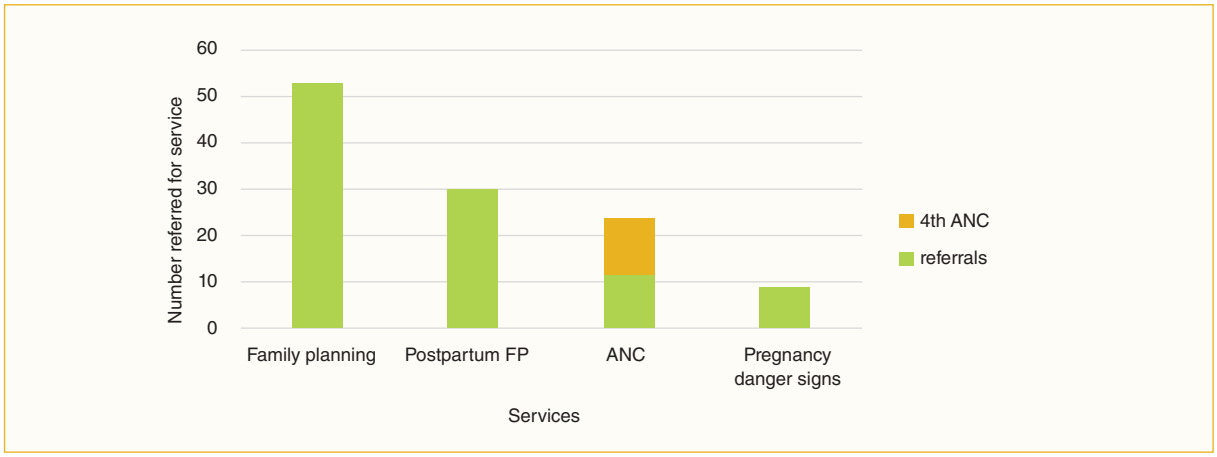
Table 7: Women referred by CHVs in the last one month before the survey

			Total	
	Kamukunji	Embakasi	Baseline*	Endline
Average	4.5	3.0	1.6	3.9
Maximum	140	125	94	170
Minimum	0	0	0	0

*** indicates postpartum family planning excluded**

Figure 3 illustrates the number of women referred by CHVs for various services in the month leading to the survey. Most women were referred for family planning (53), with half of those referred for ANC attending at least four ANC visits.

Figure 3: Referrals by CHVs in the preceding month before the survey

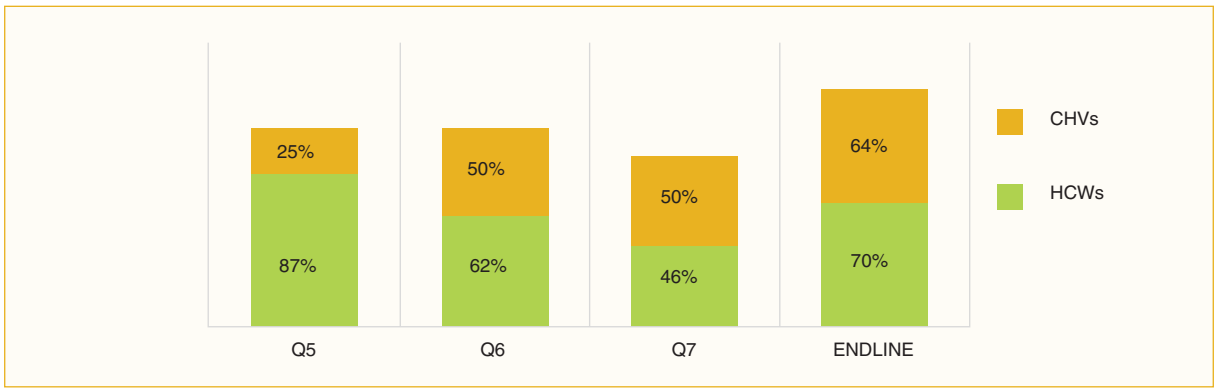


In the last three months prior to survey, CHVs referred a maximum of 12 newborns for routine medical check-ups and six to seek medical care for danger signs.

3.3.3 System usability score

Figure 4 presents the SUS scores among CHVs and HCWs, comparing the scores during implementation and at end-line. The scores among CHVs were high when the application was introduced and decreased at end-line; the inverse is seen with the HCWs, as the health facility users were not constant during the life of the project.

Figure 4: System usability score during implementation and endline



At endline the overall SUS mean score was 70% (above average) and 64% (below average) for the CHVs and HCWs respectively. The CHVs found the application easy to use and learn, while the HCWs found the web application well-integrated. Table 8 presents the scores for the 10 statements among the users. Assigning the maximum score of 5 for the positive questions means that users found the application easy to use and acceptable; a minimum score of 1 for the negative questions means that users also found the application easy to use and acceptable.

Table 8: System usability scores mean scores on the 10 statements

Positive scores (scores closest to 5 are ex excellent)	CHVs (N=39)		HCWs (N=8)	
	Mean	Std Dev.	Mean	Std Dev.
I think that I would like to use this mobile/web app frequently	4.56	.82	3.88	1.14
I thought this mobile/web app was easy to use	4.36	.99	3.38	1.06
I found the various functions in this mobile/web app were well integrate	4.31	.98	4.12	0.64
I would imagine that most people would learn to use this mobile/ web app very quickly	4.08	1.20	3.25	0.89
I felt very confident using this mobile/web app	4.56	.85	3.00	0.76
Negative scores (scores closest to 1 are excellent)				
I found this mobile/web app unnecessarily complex	2.44	1.35	2.00	0.76
I think that I would need assistance to be able to use this mobile/web app	2.44	1.43	3.12	1.36
I thought there was too much inconsistency in this mobile/web app	2.26	1.33	2.00	0.93
I found this mobile/web app very cumbersome/awkward to use	1.85	1.16	2.13	0.64
I needed to learn a lot of things before I could get going with this mobile/web app	3.36	1.44	2.88	0.99

Almost all CHVs (95%) strongly agreed that they felt confident in using the mobile app and that they would like to use it more frequently 92.3% (n = 36); 77% reported that most people would easily learn how to use the application while 88% of the HCWs found the system well-integrated (see Table 9).

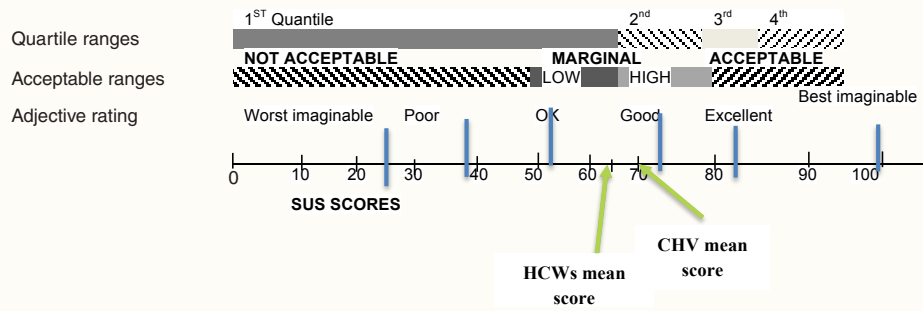
Table 9: Usability of the mobile application among users

Either agreed or strongly agreed	CHVs (N=39)		HCWs (N=8)	
	n	%	N	%
I think that I would like to use this mobile/web app frequently	36	**92.3%**	5	62.50%
I thought this mobile/web app was easy to use	34	87.2%	4	50.00%
I found the various functions in this mobile/web app were well integrate	32	82.1%	7	**87.50%**
I would imagine that most people would learn to use this mobile/web app very quickly	30	76.9%	4	50.00%
I felt very confident using this mobile/ web app	37	**94.9%**	2	25.00%

Adjective rating versus system usability score

Adjective ratings assist in the interpretation of SUS scores. The acceptability range indicates whether the evaluated system is acceptable or not. Quartile ranges illustrate the average SUS score of all SUS studies, meaning that values around the second quartile represent an average result based on all SUS studies. Figure 5 compares the SUS of CHVs (70%) and HCWs (64%) to the adjective scores and acceptability ranges showing that the mobile application was marginally highly accepted by CHVs and the web application was marginally lowly accepted by the HCWs.

Figure 5: System usability scores versus adjective scores and acceptability ranges

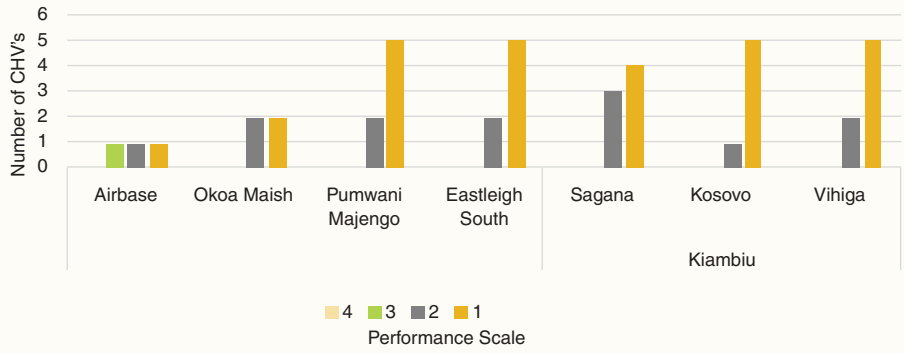


3.3.4 CHV attributes

Generally, the majority (74%) of CHVs in Kamukunji reached the project target of visiting eight postpartum women, newborns and pregnant women by end-line compared with 25% at the control site. There was no statistical difference with CHVs' ability to meet targets in relation to age, years of experience, gender, and level of education. When further analysis in terms of community units (CU) was done, all the CHVs in Airbase, Okoa Maisha, Pumwani Majengo and Vihiga reached the target: 86% in Sagana, 67% in Kosovo, and 43% in Eastleigh South. In terms of performance and consistently achieving targets, Sagana had the best-performing CHVs, with a majority scoring 2 on the performance scale compared with the other CU. On the other hand, Kosovo had the worst performance, with only one CHV scoring at least 2 on the scale.

Airbase had the best-performing CHV overall: they scored 3 on the performance scale. Figure 6 illustrates the number of CHVs per CU who reached their targets based on a performance scale where 4 is the best performing and 1 is the worst performing.

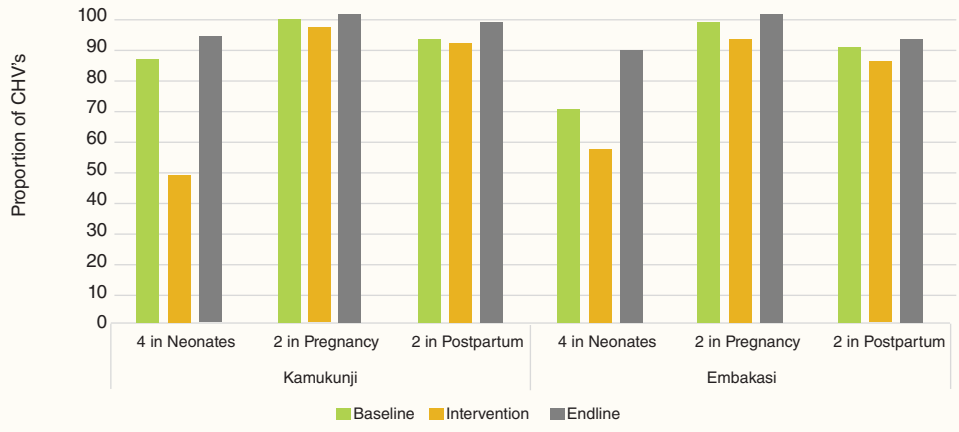
Figure 6: CHV performance by CU



3.3.5 Knowledge of danger signs

There was an improved level of knowledge among CHVs on the identification of danger signs, as seen in Figure 7. Marked improvement by 43.8% from intervention (48.5%) to end-line (92.3%) on the identification of at least four danger signs in neonates was observed in Kamukunji and by 32% in Embakasi during the same period. However, the knowledge scores of danger sign identification among neonates were lower than the knowledge scores of danger signs in pregnancy and among postpartum women.

Figure 7: Knowledge scores for the identification of danger signs among CHVs



Most cited danger signs include: failure to feed (69.8%), high fever (55.6%) and jaundice (54%) among neonates; vaginal bleeding (87.3%), and swelling of feet and hands (81%) among pregnant women; and heavy bleeding after birth (93.7%) and headaches or dizziness (66.7%) among postpartum women.

Table 10: Commonly mentioned danger signs

	Kamukunji		Embakasi		Total	
Newborn danger signs	**n**	**%**	**n**	**%**	**N**	**%**
Failure to feed	28	71.8	16	66.7	44	69.8
Signs of local infection	21	53.8	16	66.7	37	58.7
Fever (temperature above 37.5)	20	51.3	15	62.5	35	55.6
Jaundice	26	66.7	8	33.3	34	54.0
Breathing difficulties	22	56.4	9	37.5	31	49.2
Postpartum danger signs						
Heavy bleeding after birth	36	92.3	23	95.8	59	93.7
Headaches dizziness/faintness	27	69.2	15	62.5	42	66.7
Abnormal discharge	17	43.6	5	20.8	22	34.9
Pregnancy danger signs						
Vaginal bleeding	33	84.6	22	91.7	55	87.3
Swelling in hands or feet	31	79.5	20	83.3	51	81.0
Bad headache	29	74.4	14	58.3	43	68.3
Severe abdominal pain	25	64.1	13	54.2	38	60.3
High blood pressure	18	46.2	14	58.3	32	50.8

However, the proportion of CHVs who identified pre-term birth as a danger sign reduced by half from 13.5% at baseline to 6.5% in end-line. The least mentioned danger signs were high blood pressure (28.6%) and blurry vision (12.7%) among postpartum women and very pale hands and nail beds (7%), loss of consciousness (11.1%), and painful urination (14.3%) in pregnant women.

3.3.6 Challenges reported on the functionality of the application.

During the implementation, 67% of CHVs (79% in Quarter 7 and 55% in Quarter 8) reported the application 'hanging' (loading slowly or failure to load) and poor internet connectivity as challenges.

To complement the findings, qualitative studies were conducted in form of FGDs, KIIs, and IDIs. In assessing the usability of the system, three main themes were identified: 1) variations in use, 2) barriers to use, and 3) recommendations to improve use (Table 11).

1. Variation in use:

The private facility and some CHVs used the system more than health workers at the public facilities. Generally, the system was well received by those who used it and appreciated its benefit.

Positive experiences and or benefits of using the system

The system was appreciated as beneficial in improving work-life experiences, as highlighted below:

"I would like to use that phone even somewhere else leave alone this one for the phone even somewhere else I would like to use it because it makes my work easier. I see the work is good because right now I would be carrying around that big book of 514 and that 514 is on my phone so I think it is easy. I would be carrying the 100 for a referral I see it in my phone. The 513, I would still….so that one makes

my work easier because carrying these three books, they are heavy carrying with a bag because they can't fit in this bag. And now the phone, I will put it in my bag and walk with it you see now that makes my work easier." **– IDI CHV**

"…early submission of reports I would say because immediately they visit a household you can actually get the information right where you are. Personally, I can use my phone to actually check on what they are doing, by the fact that you can put in the GPRS coding, you can know that this person actually was doing this at a particular area at this particular time and not in their own household. So, when it comes to report transmission it is very prompt and you can actually make a decision concerning that particular house hold in good time." **– KII CHA**

Negative experiences in using the system

On the other hand, the processes surrounding use were a deterrent to effect use as exemplified below:

"…it has a negative because at the moment, okay there is a time I lost my phone. It was stolen and it had that line of [organisation name] and it took a lot of time three months for them to return for me the line, so there is no data I have been checking. Because you cannot check without bundles, that's one thing because if I check for that one that desktop in the office, that one the bundles you find that it's not even there. Another thing since they returned for me that line, it was last month I have not been able to access any data because the password I am using and anything it doesn't open it keeps telling me your password is wrong or your password is wrong every time every time." **– KII CHA.**

2. Barriers to use:

Several barriers to use of the system emerged. These were categorised into three sub-themes: (1) socio-political environment, (2) attitudes and behaviors of the users, and (3) issues related to the system.

The socio-political environment:

A prolonged industrial action by health workers, the contentious presidential election in the year of implementation, interrupted electricity supply, and lack of basic electric fixtures were major barriers to use. Slum settings are affected by intermittent power supply. Lack of security for gadgets resulted in the computers being kept in storage, inaccessible to clinicians.

Attitudes and behavior:

From the observations made during implementation, as well as discussions held with various key stakeholders such as health managers, healthcare workers' attitudes towards the system limited its use. In the past, development partners provided extra financial motivation to system users; without this, the intended users preferred not to use the system. Most of the clinicians at the public facilities saw the system as additional work and not something to improve their work experiences.

Issues related to the system:

For some users, issues inherent to the system, including network connectivity and the phone, were major sources of concern:

"Sometimes you get to a house and the phone hangs, you are like wah! Now what to do? You remove the battery and when you start again, before they put for us that draft input, you start again information from beginning. You start again." **– FGD CHVs Kamukunji**

3. Recommendations to improve use of the system:

Participants suggested strategies to improve usage. First, integrate the system with others in use and make it available on users' regular phones:

"If they could send that app to our phones...we just use one phone. Either they just unlock those apps; I can also use my sim card." **– FGD CHVs**

Second, provide extra financial motivation for users as well as performance-based remuneration, along with with using local languages:

"Yes! But it will only solve part of the problem the other part is how do you make them stay? So yes you can make them… you can digitize the referral tool you can digitize the coordination mechanism but how do you make them stay you must pay. So the tool needs…the tool is necessary but the tool will not succeed without additional support, yes. **– KII sub-county Medical Officer of Health**

"…the tool was easily adopted by the CHV's after subsequent trials that was done but maybe further we can also improve on the language because we work with CHV's some are very illiterate, literate semi illiterate and some just never went to school so when you use when the system is only in English, it blocks a huge number of people who could have used it. So the language barrier issue should also be taken into consideration because there are those aspects that you can easily you can select which language you want to use whether Swahili or English so that everybody is accommodated." **– KII CHA**

Table 11: User perspectives on implementing the CHV DSS

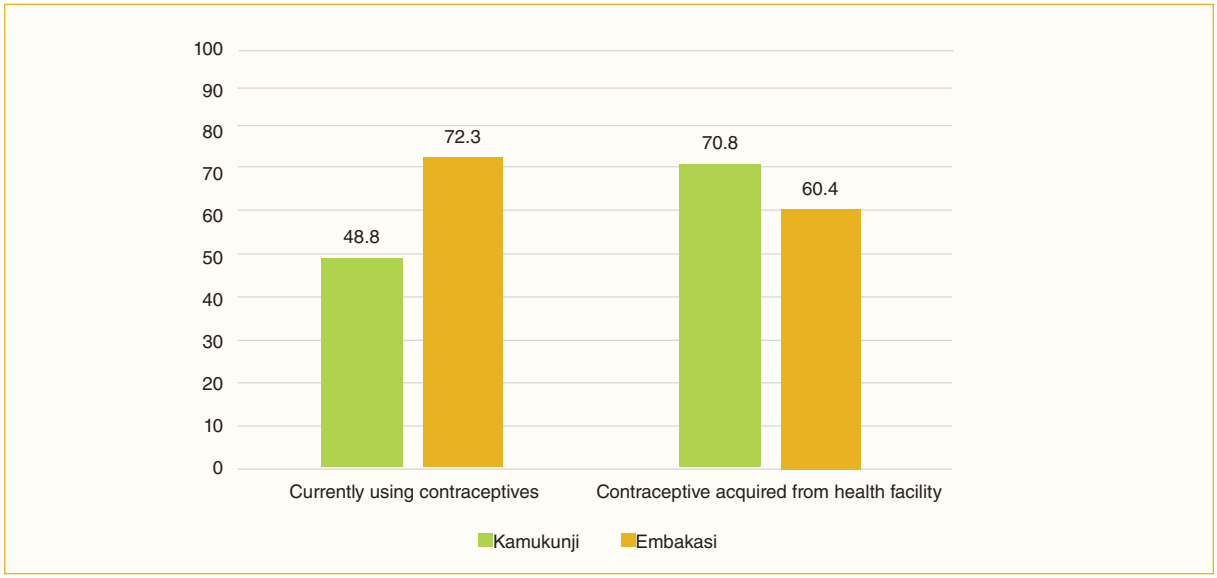
Theme	Sub-themes	Categories
Variation in use	Users' experiences	Positive experiences/benefits of using the system
		Negative experiences in using the system
		Operational challenges in using the decision support
	Non-users' experiences	Type of facility
		CHV attributes
Barriers to use	Socio-political environment	Infrastructure available
		Health workers' strike
		Electioneering period
	Attitudes and behavior	Expectations
		Lack of knowledge and skills – ICT
	Issues related to the system	Network coverage
		Nature of the gadgets
		Nature of the system
Recommendations to improve the system	Suggestions for enhancing usage	Integrate the system with others
		Explore sustainable models to motivate users to utilize the system including performance based remuneration
		ICT readiness: • Provide basic ICT skills for users • Strengthen ICT infrastructure • Continuous support in ICT

3.4 Determine the effect of the intervention on the use of MNH services and reduction of MNH complications and deaths in a slum setting

3.4.1. Family planning

Commonly known family-planning methods at the time of survey were: injections (89.7%), oral pills (69.7%), implants (67.3%), intrauterine contraceptive device (IUCD) (46.8%) and the male condom (38.3%). A majority (95.9%) knew where to obtain a family planning method; 81.7% of mothers used a family planning method to delay or prevent pregnancies, and at the time of the survey, almost 60% of the mothers were using a form of contraceptive. Figure 8 compares the proportion of women who were currently using contraceptives, and the percentage who obtained the contraceptives from a health facility. Though the current use of contraceptives was lower in Kamukunji, acquisition form a health facility was higher.

Figure 8: Contraceptive use and acquisition



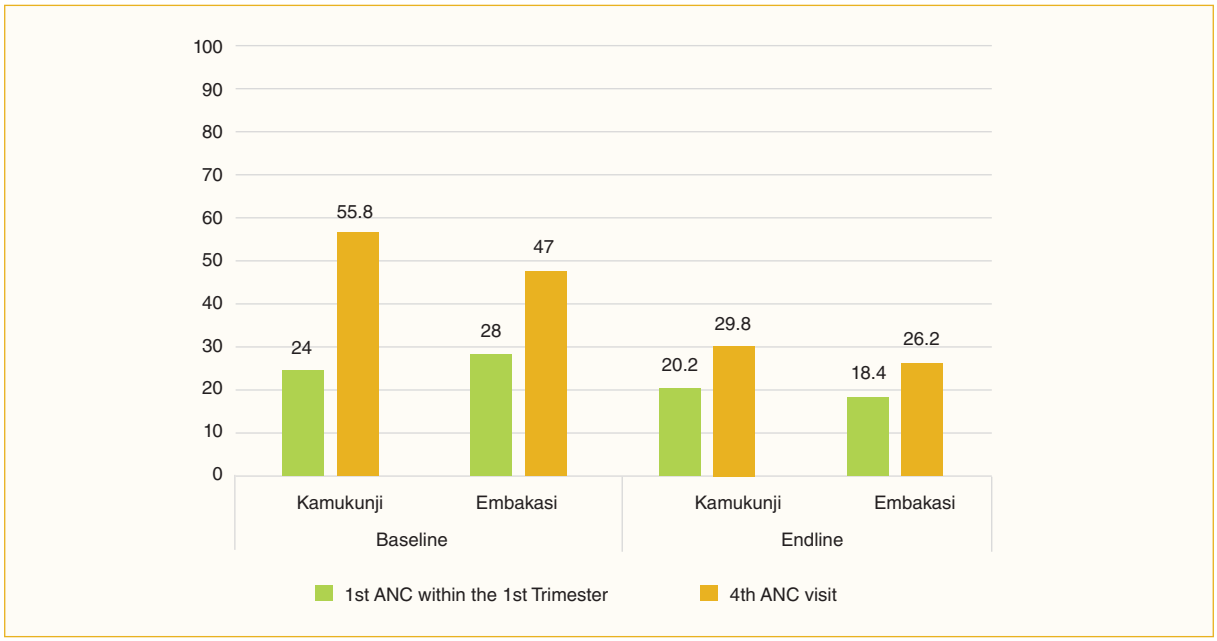
3.4.2. Antenatal care

About 40% of the respondents were pregnant, with 57% in their third trimester. About 86% were expectant with their first child, and among those who had ever been pregnant, 44% had more than three pregnancies. More than half (52.7%) of the pregnant women reported being visited by CHVs at the time of the current pregnancy, which was a 20% increase from baseline (33%). The increase was higher in Kamukunji at end-line (58%) compared with baseline (23%).

Although there was a 2.2% increase from baseline in ANC attendance, that is, 83.2% at end-line, with Embakasi having a 7.5% increase and Kamukunji a 1.9% decrease. There was a decline in the timing of first ANC attendance and the WHO recommended at least four ANC visits in both sites (Figure 9). Only 19.4% (n=44) of the pregnant women accessed first ANC within the first trimester; an overall 5.1% decline from baseline (P=0.163), Embakasi had a 9.2% decrease (P=0.100) compared with 3.6% decrease (0.458) in Kamukunji. A majority (75.3%) reported attending the first ANC in their second trimester, which was about a 23% increase from baseline.

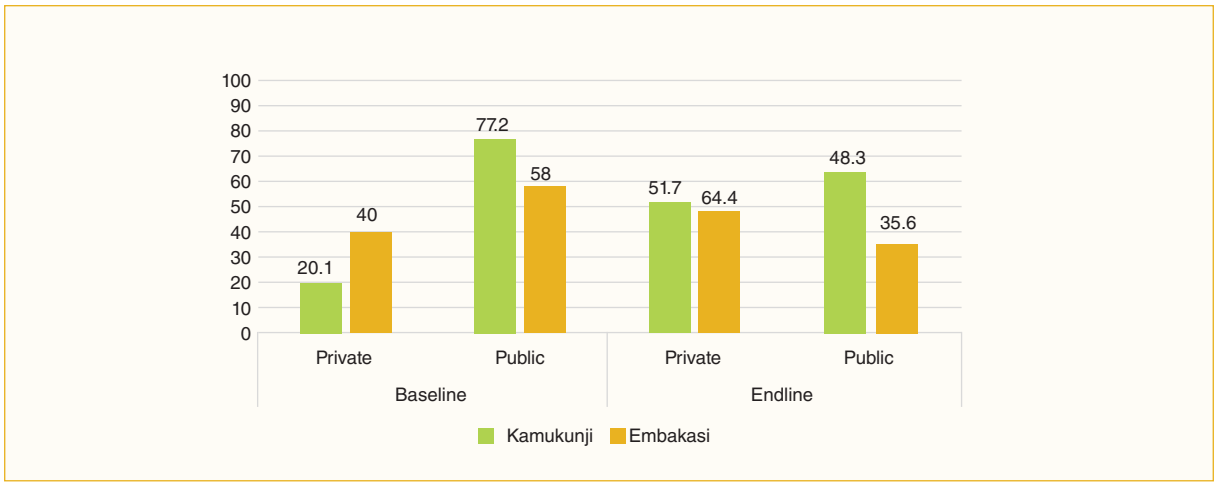
A significant 24% (n=64) decrease (P=0.002; 95% confidence interval) in the fourth ANC attendance was observed in both sites at end-line; the decline was significant in Kamukunji by 26% (P=0.000) and Embakasi by 21% (P=0.001).

Figure 9: First ANC within the first trimester and fourth ANC visits



A 97% majority reported receiving ANC service in a health facility; an increase in women seeking ANC care at private facilities was noted at end-line, 58% compared with 70%, who received ANC service at a public facility at baseline. The drop-in women accessing ANC service in public health facilities was higher by 29% in Kamukunji (Figure 10).

Figure 10: Proportion of women receiving ANC services in public vs private health facilities



3.4.3. Deliveries and postnatal care (PNC)

Institutional deliveries and skilled attendance

At end-line, there was an overall 8% decrease, from 93% to 85%, of the proportion of women who delivered their last child in a health facility. However, an increase in the proportion of pregnant women who planned to deliver at a health facility was observed: 82% at baseline to 94.9% at end-line. Similarly, a significant decrease in the proportion of women who delivered with skilled birth attendant (SBA) was observed at end-line; 87.2% VS 93% at baseline; (99% CI; = 0.004). This decrease was significant (difference -7%) in Kamukunji (99 CI; P= 0.008) and not significant in Embakasi (difference -4%; P=0.141). In both

sites, an increase in the proportion of women who delivered with unskilled birth attendance increased from 7.3% at baseline to 13% at end-line.

Complications and PNC

During the birth of their last child, about 19% of mothers experienced complications during delivery. Table 12 presents the commonly mentioned complications experienced by respondents during and after delivery of their last child.

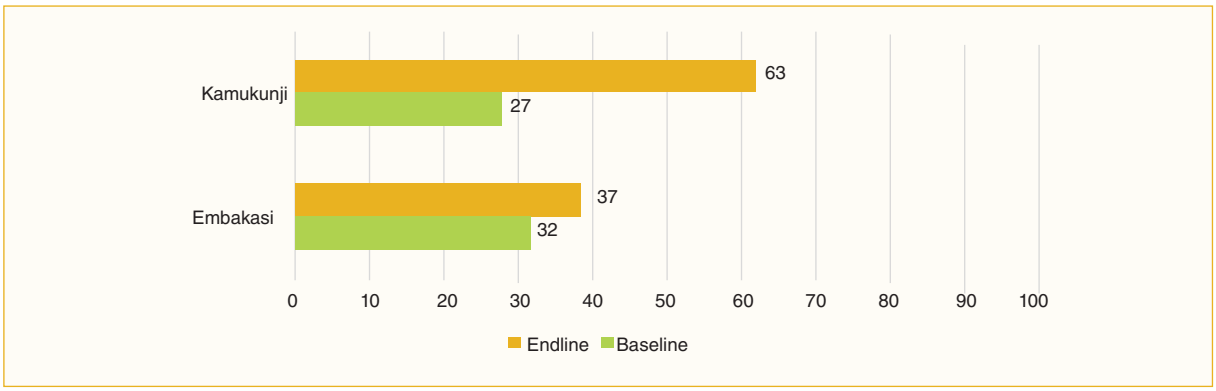
Table 12: Complications experienced during and after delivery of last child

During delivery	%	After delivery	%
Prolonged labor	30.4	Bad abdominal pain	38.1
Excessive bleeding	29.1	Painful urination/difficulty passing urine	32.4
Swollen limbs	20	Headache and dizziness	25.3
		Swollen limbs	19.9
		Heavy vaginal bleeding	17.2

*Multiple response questions

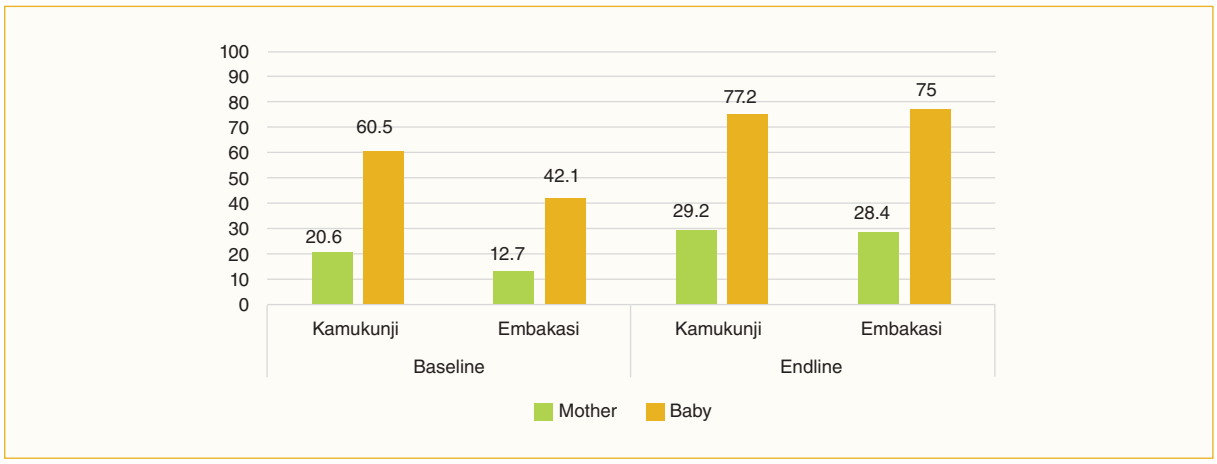
About 52% were discharged from place of birth within 24 hours after delivery; more than half, 55.3%, reported that they experienced complications two to seven days after delivery; and 49% were visited at home by a CHV after delivery with a 30% increase from baseline to end line in Kamukunji (63%) compared with Embakasi (37%) (Figure 11).

Figure 11: Proportion of women visited by CHVs after delivery of the last child



However, only 23% were visited at home by a CHV within the recommended two days after delivery, while a majority (40%) were visited by a CHV three to seven days after delivery. The proportion of mothers who attended at least two PNCs increased by 12% from 17% at baseline to 29% at end-line. Overall, the difference was significant (99% CI; P=0.0000): significant in Embakasi (difference 16%; P=0.000) but not in Kamukunji (difference 9%; P=0.27). However, at least two PNC checks for the mother remain lower than the child (see Figure 12).

Figure 12: Proportion of all new mothers (with babies under one year) and babies attending at least two PNCs



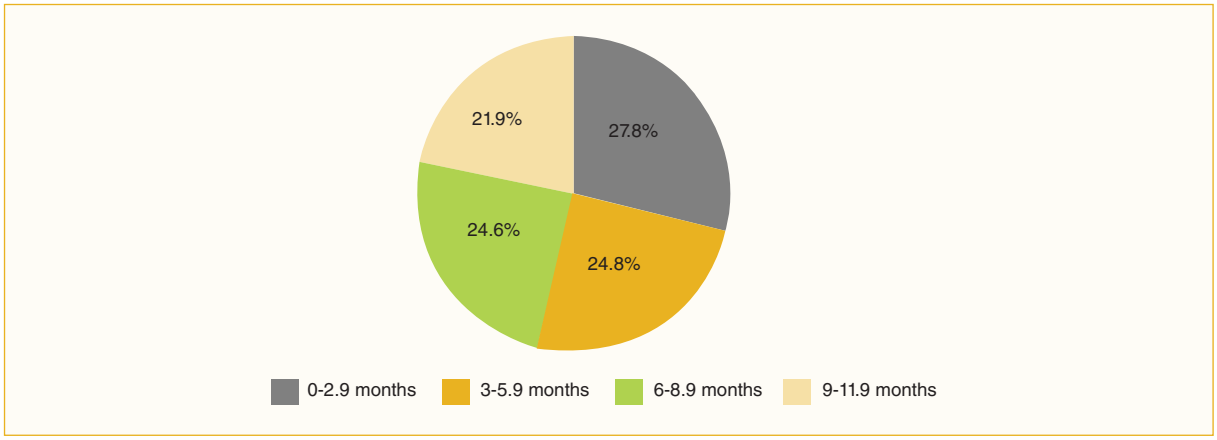
More than half (52%) of the mothers in Kamukunji reported that they were referred by a CHV to seek care at a health facility during the postpartum period, compared with 27% in Embakasi. About 71% and 76% of the mothers in Kamukunji and Embakasi, respectively, completed the referral loop. Referral by a CHV to receive postpartum family planning was reported by 38% and 20% of mothers in Kamukunji and Embakasi respectively with 65% in Kamukunji and 62% in Embakasi, completing the referral loop. Married women increase the odds of completing the postpartum Family Planning (FP) referrals by 46.5% as compared with non-married women, and Christian women were more likely to complete the postpartum FP referral as compared with the non-Christian women. Christian women increase the odds of postpartum FP completion by 153%.

3.4.4 Infant health

Characteristics of infants

About 53% of the infants below 12 months were male. The mean age of the infants was 5.6 months with the youngest child being 9 days old and the oldest being 11.9 months old (see Figure 13). The average weight at birth was about 3200 grams, with the minimum weight being 1700 grams and a maximum weight of 5000 grams. Only 3.9% of the infants were born at low birth weight: 3.6% in Kamukinji and 4.2 in Embakasi.

Figure 13: Age distribution of infants below 12 months



Breastfeeding practices

Almost all mothers (99.8%) reported that their child was breastfed at some point. Early initiation of breastfeeding, baby put to the breast within one hour of birth, was 3.6% lower at end-line (73.7) compared with baseline (77.3%). In both sites, 32% of the respondents did not initiate breastfeeding within one hour due to advice from other people. About 97% of mothers fed their child on colostrum. About 72% of mothers with children below 6 months reported that their child was only fed breastmilk since birth. Almost all the children under 6 months (98%) were breastfed the previous day. Using the WHO/ UNICEF definition of exclusive breastfeeding (EBF), using the 24-hour recall, only 58% were exclusive breastfeeding; 3% lower than the national average. The table below presents EBF at different age groups, showing EBF higher among children less than 3 months and declines by almost half among children aged between 3 to 6 months of age.

Table 13: Exclusive breastfeeding (using 24-hour recall)

Child's age	Kamukunji (%)	Embakasi (%)	Total (%)
< 3 months	79.7	72.4	76.1
3 – 6 months	33.3	38.9	36.7
<6 months	62.1	55.0	58.1

Infant morbidity

Only 18% of the mothers reported that their youngest child developed complications at birth. Mentioned complications included difficulty breathing (32%), jaundice (12%), high fever (12%) and unable to suckle/ feed (10.7%). Within the first month of life, fever (24.8%), cough (21.4), constipation (19.7) and diarrhoea (15%) were mentioned as the most common complications experienced by the infants.

Almost a quarter of the mothers reported that a CHV visited them at home when the baby was ill; 28% in Kamukunji and 21% in Embakasi. In Kamukunji, 67% of mothers reported that CHVs identified danger signs in their children during home visits, compared with 38% in Embakasi; 91% in Kamukunji were referred by CHVs to seek medical care compared with 78% in Embakasi.

Summary of key outcomes

The table below presents the key outcomes at baseline and end-line.

Table 14: Key outcomes at baseline and end-line

	Kamukunji				Embakasi East				Total			
	Baseline	End-line	Difference	P-value	Baseline	End-line	Difference	P-value	Baseline	End-line	Difference	P-value
	%	%	%		%	%	%		%	%	%	
Pregnant women who accessed first ANC within the first trimester	24	20	-4	0.429	28	18	-10	0.146	25	19	-6	0.125
Pregnant women attending at least four ANCs	56	30	-26	0.000**	47	26	-21	0.001**	41	28	-13	0.002**
Skilled birth attendant	92	85	-7	0.008**	93	89	-4	0.141	93	87	-6	0.004**
Attending at least two PNCs	20	29	9	0.027*	12	28	16	0.000**	17	29	12	0.000**
Breastfed within one hour of birth	70	76	6	0.206	72	72	0	0.983	71	74	3	0.38
CHVs identifying at least four neonatal danger signs	77	92	15	0.037*	66	88	22	0.055	73	90	17	0.006**
CHVs identifying at least two post-partum complications	86	97	11	0.053	90	100	10	0.114	87	98%	11	0.012*
CHVs identifying at least pregnancy danger signs	91	100	9	0.049*	98	100	2	0.441	93	100	7	0.030*

***** Significant at 1% level; * Significant at 5% level***

Discussions

In spite of the many pilot m-Health projects implemented in Kenya, there is limited data on lessons learned, especially in poor, urban settings. Our study uses both quantitative and qualitative methods to broaden our understanding of users' experiences with an innovative m-Health solution targeted at improving decision-making by CHVs and residents of some of the least-developed urban slums in Kamukunji, Nairobi, Kenya. In this community, implementation of m-Health solutions, as elsewhere, is affected by the context.

Adoption of the innovation was high at the community level while low at facility level. CHVs were more exposed to ICT solutions through previous interventions, thereby making it easier for them to embrace the innovation as it made their work easier. Mobile phones are lighter to carry and less cumbersome compared with the paper register, and it gave them a higher perceived social status in the community. The reverse was observed at the facility level: HCWs, especially at the public facilities, were of the general view that the web solution was cumbersome and gave them extra work. This was in part due to minimal or no exposure to ICT interventions at work.

Exposure to the decisions-support system saw an increase in CHV knowledge of danger signs in pregnant women, new mothers, and their neonates because of frequent interactions with the system. This highlights the potential of improving health literacy through e-Health, especially for CHVs. Users appreciated the role that a mobile phone played in improving their work-life experiences. We observed enhanced tracking of referrals for mothers and newborns with complications.

Lack of basic ICT literacy among health professionals was observed. As Kenya looks at harnessing m- and e-Health technologies, it is important that health workers be empowered through capacity-building, both during training and on the job. This might include integrating e-Health into existing curricula, continuous professional training, and promoting the use of distance learning for continuous education. In this way, HCWs will acknowledge and appreciate the value of e-Health in strengthening the health system. Continuous on-the-job training provided technical support during implementation, which was frequently done at the community level and was instrumental in the observed increase in confidence, acceptability and use. However, it was a challenge to maintain at facility level because of the industrial strike, in which most HCWs were unavailable and those manning the facilities were overstretched. The opportunity to provide continuous support was lost.

Whereas the study highlights the potential of digitization and mobile phones as a way forward for strengthening the community health information system and decision-making for lower-level health providers, it stresses some key challenges affecting implementation of m-Health solutions in Africa, including: scarcity of steady power supply, lack of basic information, communication and technology skills by users, weak health systems, and others [13]. Acceptance and use of ICT at the health facility

level depended on the attitudes of healthcare professionals. Poor attitudes were observed at the health facility level, which might have been due to the introduction of a specialized concept that HCWs were not accustomed to due to lack of skills. As Kenya and other SSA countries progress to ICT revolution in health, there is an urgent need to ensure that the basic support is met. Lack of ICT equipment, sporadic electricity supply and a lack of power outlets for charging mobile phones, coupled with insecurity in the area, were major hurdles faced by the intervention. Failure to create an enabling environment will always be an impediment to the successful implementation of such innovations.

Among the barriers to effective system use was the socio-political climate in 2016 and 2017, which adversely affected use of the system at the health facility level. A long electioneering period in the country characterised by uncertainty and bouts of insecurity as well as a nationwide health workers' strike affected the full implementation of the activities. The systems usability was also limited due to a shortage and unavailability of users at the community and health facility level.

During the implementation, it was noted that weak support for the health systems in general and for the community health strategy continues to affect implementation of healthcare services in Kenya. This also had an impact on the implemented activities. This observation agrees with existing reports that despite being clearly defined on paper, and its growing role in delivering vital primary health care services, there is limited government support [21, 22]. Several users expected extra financial motivation while others could not comfortably use the phones and desktop computers provided. In this light, the study further stresses the necessity in considering the behavioral determinants of data collection activities in the strengthening of health information systems.

One of the stronger functionalities of the system was the decision support tool. There was improved knowledge of CHVs in the identification of danger signs in pregnant women, postpartum women, and their newborns. As a result, there was a marked increase in the number of CHVs who mentioned health education on pregnancy, postpartum and newborn danger signs as their roles. This increase in knowledge led to an increase in the number of referrals to health facilities not only for danger signs but also for other maternal and newbornhealth (MNH) services. Mobile phone use was shown to be positively associated with higher self-efficacy (in terms of confidence in abilities) (.25, $p<.001$), which was positively associated (.16, $p<.05$) with health knowledge of maternal health practices [23].

Despite the increase in community referrals, there was a noticeable decrease in the number of CHVs who mentioned referral as one of their roles. In general, a possible explanation could be that there was a shortage of the referral tools used by CHVs, that is, the MOH 100 forms. As for the intervention site, the CHVs might view referrals as part of a functionality of the phone and not so much as their role. This corroborates with Varonen, Kortteisto, and Kaila, who found that obscured responsibilities and loss of own reasoning were some of the barriers to using a decision support system [24]. Though electronic m-health systems enable the users to make timely decisions, there is a risk of them perceiving roles essential to their job as a system role.

Study limitations

While our study provides a rich context to m-Health implementation in this setting (in Nairobi slums), we only elicit the perspectives of individuals resident and/or working in this community. This might limit our application of the decision support system, and ability to make recommendations for public health interventions. Furthermore, the short implementation period needs to be considered, especially in relation to the socio-political environment that prevailed during the period.

Conclusions

The study demonstrates the feasibility and acceptability of this type of research in a previously under-researched sub-population. It serves as a basis for future work that could highlight opportunities to respond to the persistent challenges surrounding m-Health implementation in low resource settings.

Recommendations

As more healthcare delivery models are developed, harnessing the potential of digital technologies, strengthening health systems is critical as this provides the backbone on which such innovations draw support.

General recommendations:

- **Interoperability or integration?** As the country embraces digital solutions, there is a need to debate whether proposed systems should interoperate (the ability to exchange data between two or more systems) or integrate (joining distinct systems into one) to facilitate smooth implementation, operation and efficient use these technologies.
- **Engage mobile service providers** and have them on board to address infrastructure sustainability. Heavy investments are required in equipment acquisition and maintenance as well as internet solutions.
- **Strengthen ICT skills among users** to foster greater understanding and confidence in using digital solutions and promote sustainability.
- Continuous support (application enhancement and on-job-trainings) is required at all levels from the development of user-friendly and easy-to-use applications to implementation. Where possible, development should involve the users from the development of the concept and be flexible to the changing needs of the users.
- Explore mechanisms that **protect the healthcare system from shocks** such as the industrial strike, as this is a huge deterrent in use of healthcare services and demonstrating the feasibility of an electronic/ mobile application in healthcare settings.

Specific policy-level recommendations:

- The county health department, with assistance from the national government, should explore modalities to operationalize and enforce the e-Health policy, as well as strategies and other existing policies to strengthen the enabling environment for ICT in health.
- The county health department must strengthen coordination and joint efforts to achieve greater impact by involving all stakeholders to avoid overburdening users and duplication of efforts.
- Adoption of ICT is a complex process that requires strategic partnerships. Strengthen public-private partnerships and inter-ministerial engagement to ensure ICT pillars in health are adequately supported for successful implementation and efficient use of investments.
- Invest in research to promote evidence-based solutions and decision making at all levels and develop solutions in the contexts that they apply.

References

1. Lawn, J.E., S. Cousens, and J. Zupan, *4 million neonatal deaths: when? Where? Why?* Lancet, 2005. 365(9462): p. 891-900.
2. Liu, L., et al., *Global, regional, and national causes of child mortality: an updated systematic analysis for 2010 with time trends since 2000.* The Lancet, 2012. 379(9832): p. 2151-2161.
3. Zureick-Brown, S., Newby, H.,Chou, D., Mizoguchi, H., Say, L., Suzuki, E., & Wilmoth, J, *Understanding Global Trends in Maternal Mortality* International Perspectives on Sexual and Reproductive Health 2013. 39(1): p. 32-41.
4. UN *Transforming our World: Agenda 2030 for Sustainable Development,* . 2015.
5. Osborn, D., Cutter, A., & Ullah, F, *Universal Sustainable Developement Goals.* 2015, Stakeholder Forum, commissioned by the UN Development Program: Geneva, Switzerland.
6. KNBSandICFMacro, *Kenya Demographic and Health Survey 2008-09* 2010, Kenya National Bureau of Statistics (KNBS) and ICF Macro: Calverton, Maryland.
7. KNBS, *Kenya Demographic and Health Survey 2014.* 2015, Kenya National Bureau of Statistics (KNBS): Nairobi, Kenya.
8. Blaya, J.A., H.S. Fraser, and B. Holt, *E-health technologies show promise in developing countries.* Health Affairs, 2010. 29(2): p. 244-251.
9. Braun, R., et al., *Community health workers and mobile technology: a systematic review of the literature.* PloS one, 2013. 8(6): p. e65772.
10. Simba, D.O., *Application of ICT in strengthening health information systems in developing countries in the wake of globalisation.* African Health Sciences, 2004. 4(3): p. 194-198.
11. Zab, S., *Whitepaper: The growth of the smartphone market in Kenya.* 2015.
12. CA, *First quarterly sector statistics report for the financial year 2015/2016 2015,* Communications Authority of Kenya (CA): Nairobi. p. 1-28.
13. Omulo, C., New study shows more Kenyans have internet access, *New study shows more Kenyans have internet access, in Daily Nation.* 2017: Nairobi.
14. Drouillard, M., *Digital Entrepreneurship in Kenya 2014,* in *GSMA2014*. 2014, GSMA, Omidyar Network, UKaid.

15. Demombynes, G., A., *Kenya's mobile revolution and the promise of mobile savings. World Bank Policy Research Working Paper (5988).* 2012.

16. Talbot, D., *Kenya's mobile prescription: local programmers and homegrown business models are helping to realize the vast promise of using phones to improve health care and save lives. Technol Rev (Camb, Mass). 2012. 115.* Technol Rev (Camb, Mass), 2012. 115.

17. GOK, *Kenya National e-Health Strategy 2011–2017,* M.o.M.S.M.o.P.H.a.S.G.o. Kenya-GOK), Editor. 2011: Nairobi.

18. Bakibinga, P., et al., *The role of a decision-support smartphone application in enhancing community health volunteers' effectiveness to improve maternal and newborn outcomes in Nairobi, Kenya: quasi-experimental research protocol.* BMJ Open, 2017. 7(7).

19. Bakibinga, P., Kamande, E., & Kyobutungi, C, *Harnessing Public-Private Partnership to improve Maternal, Newborn and Child Health (MNCH) services and outcomes in Nairobi slum settlement: End of Grant Report.* 2016, African Population and Health Research Center: Nairobi, Kenya.

20. Brooke, J., *SUS-A quick and dirty usability scale.* Usability evaluation in industry, 1996. 189(194): p. 4-7.

21. Wangalwa, G., et al., *Effectiveness of Kenya's Community Health Strategy in delivering community-based maternal and newborn health care in Busia County, Kenya: non-randomized pre-test post test study.* The Pan African Medical Journal, 2012. 13(Suppl 1): p. 12.

22. McCollum, R., et al., *Exploring perceptions of community health policy in Kenya and identifying implications for policy change.* Health Policy and Planning, 2016. 31(1): p. 10-20.

23. Lee, S., A. Chib, and J.-N. Kim, *Midwives' Cell Phone Use and Health Knowledge in Rural Communities.* Journal of Health Communication, 2011. 16(9): p. 1006-1023.

24. Varonen, H., T. Kortteisto, and M. Kaila, *What may help or hinder the implementation of computerized decision support systems (CDSSs): a focus group study with physicians.* Fam Pract, 2008. 25(3): p. 162-7.

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