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Implementing Surveillance and Outbreak Response Management and Analysis System (SORMAS) for Public Health in West Africa- Lessons Learnt and Future Direction

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Authors' contributions

Author GP was scientific lead of field implementation, initiated and wrote the first draft. Author OOA coordinated implementation, conducted the analysis and final draft of this manuscript, author GK was scientific lead of the overall project and conceptualized the study. All authors actively contributed to design of SORMAS, as well as implementation and evaluation of its piloting and revision of the manuscript.

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ABSTRACT

Background: Mobile devices have the potential to strengthen surveillance in sub-Saharan Africa. Electronic surveillance (eSurveillance) is the use of electronic systems to facilitate public health surveillance. Mobile health (mHealth) is the use of mobile phone technology for health-related purposes. SORMAS is a new system developed as a tool for surveillance and public health response management of infectious diseases.

Aims: To pilot a new mobile phone based Surveillance and Outbreak Management and Analysis System (SORMAS) application in Nigeria and document the experience and challenges.

Place and Duration of Study: Health facilities and Local Government areas in Kano and Oyo States, Nigeria, West Africa and Abuja, Nigeria, West Africa between December 2014 and July 2015.

Methodology: The development of the tool included contributions from six organisations in three different countries. Experience with the management of the prior Ebola Virus Disease outbreak in the country served as blueprint for tool design. We used the Integrated Disease Surveillance and Reporting system as reference for the data model. SORMAS was piloted in over 60 health facilities of 16 Local Government Areas (LGA) in Oyo and Kano States. We analysed meeting reports training evaluations and supervisory visits to describe the process and identify challenges.

Results: It took 8 months from initiation to piloting of the newly developed tool. The process was characterized by early involvement of stakeholders in the design process, adherence to existing workflows and data standards and systematic evaluation of training and piloting. Challenges included user friendly login procedures and geographic separation of team members.

Conclusion: Early involving authorities and other stakeholders is crucial for implementation of novel eHealth tools. The need for prior training and continuous supervisory availability on site should not be underestimated even for user friendly tools and it is preferable to have IT-programmers, content experts and future users work in geographic proximity to enhance exchange on needs and technical capabilities.

Keywords: Implementing; public health; outbreak; SORMAS; Nigeria; West Africa.

1. INTRODUCTION

In 1998, majority of African countries (43/46) adopted the Integrated Disease Surveillance and Response (IDSR), a WHO-AFRO strategy for improving national public health surveillance and response capacities. In 2010, the IDSR was updated to reflect requirements of the International Health Regulations (IHR) which are legally binding to the states [1]. The IHR 2005 defines core capacities for the national surveillance and the response system as basis for an early warning system for events that can constitute a public health emergency of international concern [2].

The Ebola Virus Disease (EVD) outbreak in West Africa was unprecedented with regard to geographical distribution, numbers of individuals affected and deaths. As of 19th July, 2015, in the countries with intense transmission, there was a total of 27,705 reported confirmed, probable, and suspected cases of EVD, with 11,269 reported deaths [3]. In June 2015, the Africa Union created a Regional Centre for Disease Control for the West African Region, as an acknowledgement of the need to strengthen surveillance of epidemic-prone diseases in the region. Empowering frontline health workers and communities is a key element for surveillance [4]. In the updated guidelines for IDSR, one critical gap identified was the lack of logistic and communication capacities in a significant numbers of districts in the 45 countries assessed [1]. Although some countries are using electronic systems for data collection, compilation and reporting, most African countries are still using paper based tools [1].

The use of mobile devices has the potential to strengthen surveillance systems by improving timeliness, data completeness and data quality especially in areas with difficult access [5]. Electronic surveillance (eSurveillance) is defined by WHO as the use of electronic systems to facilitate public health surveillance functions of prevention, prediction, detection and response for any acute public health event [6]. eSurveillance has the potential to enable local health staff to contribute better to surveillance [6]. eSurveillance i.e. collecting data real-time from the health care providers, can also help to ensure an early warning and response for outbreaks and its need has been particularly visible during the Ebola Virus Disease outbreak in West Africa [6,7,8]. Mobile health (mHealth) is the use of mobile phone technology for health-related purposes and has reportedly been used for medical adherence, health care worker communication, health education and disaster response [9,10]. mHealth is one major component of eHealth, which refers to the utilization of information and communication technology for health, including data transmission and video telecommunication via the Internet [11].

The growing infrastructure and penetration of broadband coverage in developing countries offers the opportunity to use electronic systems for public health purposes, also providing the prospect of linking smartphones to web applications for epidemiology data collection using a central database, which can provide the tools for the submission, visualization and analysis of data collected by many users from many different locations [7].

Recently a number of publications have reported about the concepts and outputs of surveillance systems using mobile phones [12] However, the special methodological challenges of implementing such new technologies especially in African countries are rarely addressed. The authors aim to report their experiences of implementing the Surveillance, Outbreak Response Management and Analysis System (SORMAS) tool in Nigeria and identify lessons that might be useful for future attempts to implement novel e-health tools particularly in the setting of sub-Saharan Africa.

SORMAS is a new system which was developed with the aim of improving the control of the West-African Ebola Epidemic in 2014/15. SORMAS was designed as a tool for surveillance and public health response management of infectious diseases in general. SORMAS offers mobile phone based and web based multi-directional connectivity for all personnel involved in the process of notifying and validating notifiable infectious diseases, managing the infections control procedure resulting from them, including the process of following up on persons who had contact with cases. Contact officers, hospital informants and surveillance officers (users at LGA and facility levels) were provided with mobile phone based interfaces, while rumour officers, surveillance supervisors, contact supervisors and case supervisors (users at the state level) used web based interfaces. A detailed description of the development and design of the SORMAS application has been published elsewhere [13].

At the onset of the project, to provide inputs in assessing the requirements and the processes that might be involved in piloting the SORMAS tool, design thinking workshops were held in Nigeria and Germany. Subsequently, stakeholders from Rivers and Lagos (the two states affected by EVD in 2014), the Nigeria Centre for Disease Control (NCDC), Port Health and Animal Health were brought together to share their experience with the EVD outbreak and routine surveillance, the problems encountered and their expectations in future. The Open Data Kit (ODK) used during the EVD outbreak was already extended in both states on mobile phones for routine surveillance. Concerns

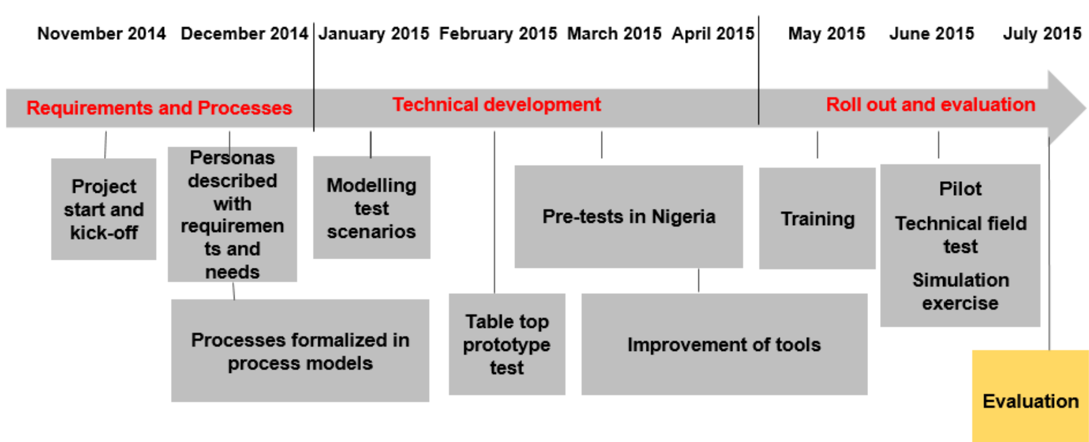

Fig. 1. Summary of workflow of events for the SORMAS Pilot project

were expressed about the disconnect between the animal health surveillance and human health surveillance, also, issues were raised about the manageability of the surveillance data being collected by ODK. The review meeting was then intimated of the development of a tool which promises to solve some of the problems in future. The stakeholders were then taken through the screen shots of the new tool and some of its features. Discussion about the need to coin for the tool came up and the stakeholders brainstormed and unanimously agreed on ''Surveillance and Outbreak Response Management System- Nigeria'' (SORMAS-N) which was later revised to be ''Surveillance and Outbreak Response Management and Analysis System- Nigeria". This was later followed by the formalisation of the process models and the final technical development of the SORMAS application before the final roll out. (see Fig. 1 for the summary of the process workflow of the SORMAS project).

2. METHODOLOGY

2.1 Selection of Pilot Sites

Jointly with the NCDC, the authors decided to conduct the pilot in two different states (Oyo and Kano States) on the basis of the following three criteria: a) they had not been affected by the EVD outbreak, b) no other mobile phone based surveillance project was running in these states, and c) they represent states of different characteristics with respect to demographics, epidemiology and infrastructure.

The NCDC facilitated and coordinated the pilot by informing the State Ministries of Health (SMoH) about the project and announcing advocacy visits by members of the Nigeria Field Epidemiology and Laboratory Training Program (NFELTP) participating in the SORMAS pilot project. The objective of the advocacy visits was to explain the purpose of the pilot, the time schedule and work load to be expected by the staff in the participating health facilities.

2.2 Selection of Pilot Diseases

For pilot-purpose, the authors selected cholera, measles and avian flu as they represented a high priority for the NCDC and because they encompass different aspects of epidemiologic management, such as interfaces with environmental health and sanitation (cholera), vaccination programs (measles), and veterinary health (avian flu). In order to test the complex outbreak management capacity of SORMAS for EVD in the absence of a true EVD outbreak, we ran a simulation exercise using inject with scenarios of events of a virtual disease with the same epidemiological features as EVD. For this purpose, this virtual disease was named ''exercise disease''. In the inject, participants were provided daily with information on "exercise disease". This data came from simulated scenarios and generated by a computer. It gave an impression of an EVD outbreak with cases and contact persons as realistic as possible – but names, places and stories were invented. This necessitated the need for the inclusion of an application for contact tracing (Fig. 2).

2.3 Recruitment of Participants and Facilitators

We designed SORMAS so as to mirror closely the existing infrastructure and the needs of the existing surveillance staff. This also predetermined the assigning of respective surveillance staff to the different user types (personas) within SORMAS pilot. Exceptions had to be made for the personas not regularly established in the routine surveillance system but to be implemented ad hoc upon an EVD outbreak (i.e. contact officer, contact supervisor and case supervisor). The specific assignment of the piloting participants to the respective persona is summarized in Table 2.

2.4 Choice of Hardware and Data Plan

The authors based the selection criteria for IT hardware on the table top prototype tests previously conducted in Germany: The prototype test conducted showed that the appropriate device for the developed apps should have minimum of the criteria in the Table 1 (see Table 1). So, based on these criteria and the availability of the phone brand with the recommended features within the country, we purchased 104 smart phones of LG Bello brand android OS 4.4.2, 1 GB RAM, 8 GB storage. Also, data plan of 6 GB for 30 days, were recommended by the end users as being adequate for use, the service provider with the best penetration in the selected LGAs in Kano and Oyo State were also chosen.

Fig. 2. Contact Tracing application (The first screen shot shows the list of tasks for the contact officer for that day assigned by the contact supervisor, the second screen shot shows the details of one of the assigned tasks, while the third and fourth screen shots show part of the different steps in conducting a contact follow-up interview)

Table 1. The phone features and the recommended specifications

Phone feature	Specification
Operating system	Android 4.4
Display	5.0''
Resolution	1280×720 Pixel
Battery	Min.2070mAh
Material glass	Gorilla-Glass,3
Network standard	GPRS, EDGE, HSDPA, HSUPA, $HSPA^+$
Navigation	A-GPS, GLONASS
RAM	Min. 1 GB
Storage	Min.8GB, SD Card Slot
CPU	Min. 4x 1.20GHz, Cortex-A7

2.5 Scheduling of the Pilot

Given the time constraints of the overall project, the pilot was scheduled before having finished developing and testing a pre-test version of SORMAS. The time was initially set to March 2014, where the highest number of Measles cases was to be expected.

2.6 Training of Participants

The aim of the training was to introduce future users of SORMAS to the purpose and design of the system, refresh their knowledge about infectious disease surveillance in general and to train them on the use of the SORMAS apps. The training also covered basics on epidemiology and outbreak investigations, as well as a description of the management strategy adopted by the Nigerian Emergency Operation Centre during the Ebola Virus Disease Outbreak.

An entry questionnaire was used to collect data on participants' experience with surveillance, smart phones, laptop and eSurveillance. To evaluate the immediate effect of the training on participants, we conducted a pre- test and post-test consisting of questions on EVD, avian influenza, outbreak investigations, surveillance, as well as knowledge and attitude with respect to SORMAS. To also assess the quality of the training and participants' satisfaction, eight questions with Likert scale (Table 4), three Yes-No questions (Table 5) and five open ended questions (Table 6) were employed. We transferred the paper based questionnaire into Excel and analysed the data with the same. The questionnaires were conducted in an anonymous way, not allowing re-identification of the participants.

2.7 Supervision and Quality Control

For each LGA, we identified support persons as field supervisors (Oyo state: residents of the NFELTP, Kano State: Officers of the NFELTP-Nigeria Stop Transmission of Polio (NSTOP) Program) visiting the LGA at least once weekly for support and troubleshooting. We also installed a hotline phone number for all participants which they could call if explanation or support with the pilot was needed.

2.8 Pre-testing and Agile Programming of Prototype

We assessed the requirements for the tools in collaborative effort of public health experts and IT experts: Nigerian public health staff who had worked in the Emergency Operation Centres (EOC) in Lagos and Port Harcourt during the EVD outbreak in Nigeria, staff from the Nigeria Centre for Disease Control and German Epidemiologists on one hand and IT specialists from Nigeria, United States of America and Germany on the other hand. Details of this process had been described [13]. Before introducing the SORMAS tool to the participants of the pilot, we ran series of pre-tests in Abuja, Nigeria. The aim of the pre-tests was to assess technical functionality within Nigerian infrastructure, comprehensibility of work-flow, and compatibility of labels and functions with the established surveillance system within the country. During the pre-tests, we conducted regular tele-conferences in variable frequency depending on the need, ranging from daily to bi-weekly in order to further refine the applications in an agile programming attitude.

2.9 Ethics and Data Confidentiality

Ethical approval was obtained from the ethical committees in Kano and Oyo State. In parallel, the study was also submitted to the ethical committee of the Medical board of lower Saxony in Germany. Data confidentiality was also maintained by ensuring all the mobile devices and laptops for the pilot were secured with unique usernames and passwords.

3. RESULTS AND DISCUSSION

3.1 Selection of Pilot Sites and Pilot Diseases

The SMoH of the two states approached for participating in the pilot (Kano and Oyo state) accepted the invitation, expressing high expectations towards the added value of SORMAS. Kano State and Oyo State have a population of 9.3 and 5.6 million inhabitants and a population density of 454 and 204 inhabitants/sq km, respectively [14]. In 2013, the mortality of children less than five years was higher in Kano compared to Oyo (237 versus 75 per 1000 live births), whereas the vaccination coverage of measles was 25% in Kano State and 45% in Oyo State [15].

In the selected LGAs in Kano and Oyo, there were in average four and 22 Primary Health Care Centres per LGA, respectively. Although, not initially selected through the authors' sampling approach, two tertiary care hospitals were invited to join the pilot because they had expressed strong interest in participation and because they play an instrumental reference function towards the other health facilities.

Due to the limitation of funds available for the pilot, it was impossible for the pilot to be done in all the 44 and 33 LGAs in Kano and Oyo States respectively. So, within each of the two states, we randomly selected four urban and four rural LGAs (8 LGAs per state). From each LGA, the authors recruited two private and two public health care facilities by purposive sampling (4 facilities per LGA) based on the volume of patients seen in the facility and the likelihood of finding the cases of interest. The authors aimed to recruit one primary and one secondary public health care facility in each LGA. However, if a secondary health facility was not present in the LGA, two primary health care centers were selected instead. An additional facility dedicated to the care of cholera patients was also purposely included in Oyo State which was not situated in any of the 8 LGAs randomly selected, this was of a necessity because cholera was one of the priority diseases for the pilot project. A tertiary health facility was also selected in each of the two participating states (making 34 selected facilities in Oyo and 33 facilities in Kano).

A designated facility for the care of EVD was also selected in each of the 2 states.

3.2 Recruitment of Participants and Facilitators

No additional selection or recruitment procedures was needed for facilitators, field support staff and logisticians, their recruitment was mainly decided on the basis of their skills and availability. However, the selection of pilot site determined the selection of the other personnel , the allocation of these other personnel to different roles in the pilot was done to mirror closely their everyday surveillance routine duties e.g. the State Disease Surveillance and Notification Officer who is routinely charged with the filling of the IDSR rumour log form was assigned to play the role of the Rumour Officer, the LGA Disease Surveillance and Notification Officer who is routinely in charge of surveillance in his LGA played the role of the Surveillance Officer, the State Epidemiologist who routinely supervises all activities related to surveillance in his state played the role of the Surveillance Supervisor e.t.c.

Within each of the two states, the State Epidemiologist and the State Disease Surveillance and Notification Officers (DSNO) were recruited as the Surveillance and Contact Supervisor and the Rumour Officer for the pilot project respectively. In each of the 8 selected LGAs per state, the LGA DSNO and the LGA assistant DSNO, were each recruited to play the role of the Surveillance Officer and Contact Officer respectively. Also, for each of the selected health facilities including the tertiary facilities and the dedicated cholera facility in Oyo (34 facilities in Oyo and 33 facilities in Kano), the hospital surveillance focal person was recruited to play the role of hospital informant and the physicians in charge of each designated facility for the care of EVD were recruited to play the role of case supervisors.

The result of the recruitment and staff assignment is displayed in Table 2.

3.3 Choice of Hardware and Data Plan

Based on afore mentioned criteria, we purchased 104 smart phones, for the rumour officer, hospital informants and contact officers and eight laptops for the supervisors. The selection of the data plans, however, had to be changed for some of the participants, as mobile phone connectivity proved to be variable within a LGA, so that for some participants, new data plans had to be procured, which provided better coverage for the specific facility they work in.

3.4 Pre-testing and Agile Programming of Prototype

The pre-testing proved to require much more time than anticipated. The pre-testing also led to a change in design, as it demonstrated the need to provide two additional mobile applications (for surveillance officer and hospital informant) which were initially not foreseen to be included in the pilot. In consequence, as the pilot had already been scheduled, time did not suffice to develop a proper customized app for surveillance officers- instead the app for rumour officers was adapted

Table 2. Assignment of personnel within the Nigerian public health system to specific roles within the SORMAS pilot in Oyo and Kano States

Personnel participating in the study	Role (persona) of officer during SORMAS pilot	Number of officers participating in the pilot
State Disease Surveillance and Notification officer	Rumour officer	2
Hospital clerk/ Hospital surveillance focal person	Hospital informant	67
LGA Disease Surveillance and Notification Officer	Surveillance officer	18
LGA Assistant Disease Surveillance and Notification Officer	Contact officer	17
Physician in charge of isolation facility for EVD	Case supervisors	2
State epidemiologist	Contact supervisors	2
State epidemiologist	Surveillance supervisor	2
NFELTP graduates and Resident Advisor, WHO surveillance officers, NCDC personnel	Facilitators for training	8
NFELTP graduates, NFELTP Resident Advisor and NFELTP data personnel,	Desk-top tester of prototypes	4
NFELTP IT personnel, NFELTP administrators and Nigeria Ebola EOC IT personnel	Logisticians for installation, cell phones, workshops etc	5
NSTOP staff, NFEETP residents	Field supervisors and field support staff	20

to provisionally meet the need of the surveillance officer (Fig. 3). Pre-testing proved to be critical for the overall process and the time and resources allocated to it were largely underestimated. Additional complexity arose from the fact that the actual IT developers had no field experiences and also no prior expertise in medical issues or epidemiology, and again, IT developers were located in the USA and Germany and were not able to travel to Nigeria for conducting their work in proximity to the future field of application. So, prior to the final development of the apps, epidemiologists and an IT specialist who had vast knowledge of surveillance in Nigeria and experience in Ebola Outbreak Response had to go to Germany to meet in session for several hours (approximately 40 hours) with epidemiologists and IT developers from USA and Germany.

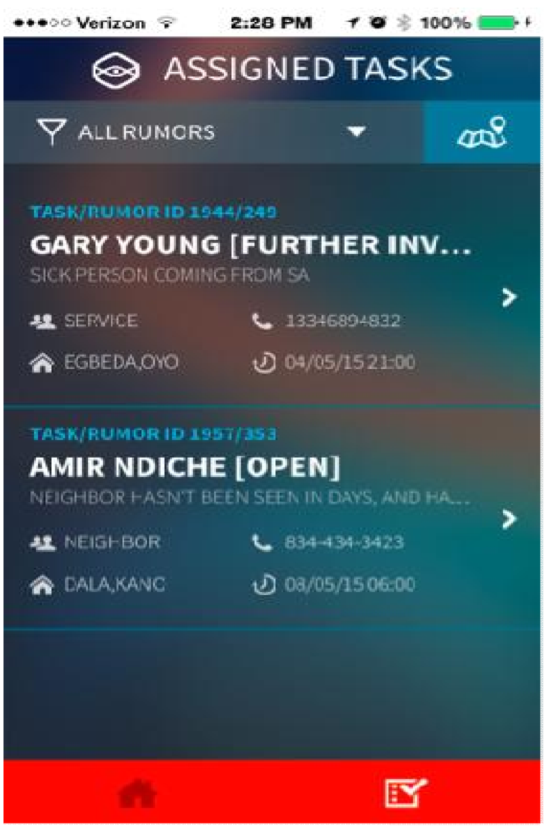

Fig. 3. Surveillance Officer's app (showing different rumours and their details assigned to the surveillance officer by the surveillance supervisor to be investigated)

3.5 Scheduling of the Pilot

The pilot had to be postponed twice because of changes in the schedule of the presidential elections, which would have impeded the undisturbed execution of the pilot. A third delay was necessary because the pre-testing showed that the user interfaces needed further improvement and also because the generation of the exercise injects for EVD proved to be more time consuming than expected. Overall, the pilot finally started 3 months later than initially foreseen between June 8, 2016 and July 17, 2016.

3.6 Training of Participants

We conducted a training workshop in Kano state, lasting from 27th of May, 2015 until 28th of May 2015 for all foreseen field users of the SORMAS application during the pilot and their supervisors and mentors. Likewise, another workshop took place from 13th of May, 2015 until 14th of May, 2015 in Ibadan, Oyo state.

The trainings commenced at 8:30 am daily and ended at 5:00 pm with a 90 min break in between for tea and lunch. The workshop consisted of lectures on general surveillance principles (30 min), lectures on specific management experiences with the EVD outbreak in Nigeria (45 min), discourse on the use and care of hardware (45 min), introductory lecture on how to use SORMAS (30 min), introduction to simulation exercises (1 hour 30 min), practical group work on using SORMAS (4hours 15 min), distribution and registration of mobile devices (30 min) and discussion about the organizational issues of the pilot and the evaluation of the project (1 hour). The result of the evaluation of the immediate effect of the training on participants is shown below (Table 3).

The assessment of the quality of the training by participants and their satisfaction with the training using Likert scale questions, (Table 4), Yes-No questions (Table 5) and open ended questions (Table 6) are all shown in the tables below.

3.7 Participants' Experience

The participants had in average three years six months working experience in surveillance. Among them, 85 (72.5 %) had previous experience with smart phones, while more than half 63 (64.2%) had experience with a laptop. Most participants 100 (97.1%) had never used an electronic management system tool for surveillance.

Table 3. Participants' pre and post test scores

Respondents (n)	Mean pre-test score (SD)	Mean post-test score (SD)	Paired 't' statistics (P value)
Kano State (51)	9.47 (5.42)	16.61 (5.92)	10.73 (<0.001)
Oyo State (55)	11.58 (4.99)	19.00 (5.28)	13.61(<0.001)
Both states (106)	10.57 (5.29)	17.96 (5.70)	17.13(< 0.001)

Table 4. Likert scale training evaluation questions

Evaluation questions	Number of respondents	Minimum likert value	Mean likert value	Maximum likert value
Workshop objectives were met	78	1	4.2	5
Adequate time was allotted for explanations/practice	80	2	4.4	5
The materials provided were satisfactory	80	1	4.5	5
Overall the workshop was satisfactory	80	1	4.4	5
Rating of the visuals	80	3	4.4	5
Rating of the sound	80	2	3.9	5
Rating of the meeting venue	80	2	4.1	5
Rating of the training handouts	80	3	4.2	5

Table 5. Yes-No training evaluation questions

Evaluation questions	Number of respondents	Number answering Yes(%)	Number answering No (%)
Do you feel prepared for the pilot testing?	79	78 (98.7)	1 (1.3)
Has the concept of the simulation become clear to you?	80	79 (98.8)	1 (1.2)
Are your tasks within SORMAS concerning exercise disease clear to you?	80	77 (96.3)	3 (3.8)

Table 6. Open ended training evaluation questions

Open ended questions	Summarised responses given
What did you like best about the workshop?	• "I learnt more about diseases e.g. EVD, measles, cholera, avian influenza" (4 respondents) • "the use of SORMAS, the concept of SORMAS, the idea of software for data collection" (7 respondents) • " I like the practical aspect", ''the way the practical is organised'' (10 respondents) • ''using smartphone'',' introducing smart phone to participants'', ''how to use smart phone'', ''I like the smartphone'', ''sending data through GSM'' (18 respondents) • ''the presentation by facilitators'', ''full explanation at the end of each presentation'', the way facilitators gave their lectures'' (15 respondents) • ''the organisation of the training'' (5 respondents) • ''the friendliness of the facilitators'' (1 respondent) • ''the workshop is very interesting'' (2 respondents) • ''the venue'', ''convenient venue'', ''the place where the workshop is scheduled'' (5 respondents) • ''it will help Nigeria''(1 respondent) • ''it will improve surveillance'' (2 respondents) • ''All the aspect of the training'' (1 respondent)

	• No response - (9 respondents)
What did you like least about the workshop?	• ‘‘the food is not OK, they did not give us amala’’, ‘‘The food’’, ‘‘ food too peppery’’ (8 respondents) • ‘‘lack of time keeping’’ (1 respondent) • ‘‘The way you lectured us’’, ‘‘the method you used in training the participants’’ (2 respondents) • ‘‘Not involving all the LGAs’’ (1 respondent) • ‘‘Bilingual presentation’’ (1 respondent) • ‘‘how to use the smartphone, I am not satisfied’’ (1 respondent) • ‘‘Nil’’ (8 respondents) • ‘‘the sound is not adequate’’ (2 respondents) • ‘‘the stipulated 2 days for the workshop was too short’’ (1 respondent)’’ • ‘‘the connectivity’’ (1 respondent) • ‘‘our institution’s invitation not arriving at the right time’’, ‘‘the organisers failed to send invitation letters to our institution and boss in order to give us permission to come’’ (2 respondents) • ‘‘All practical aspect’’ , ‘‘the practical due to poor connectivity’’(2 respondents) • ‘‘the accommodation was not up to standard’’ (2 respondents) • ‘‘the remuneration is not O.K’’, ‘’the remuneration is low’’ (3 respondents) • ‘‘training materials too cumbersome’’ (2 respondents) • No response- (45 respondents)
Open question about the smartphone and laptop handling?	• ‘‘Why are they collecting the smartphones back’’? (1 respondent) • ‘‘how can we save new cases we are adding to the app’’?(2 respondents) • ‘‘I am concerned about network issues’’ (4 respondents) • ‘‘How do I manage to charge the phones with regular power outages’’? (4 respondents) • ‘‘the steps to follow for notification are not really clear’’ • ‘‘none’’ (4 respondents) • No response- (59 respondents)
Open question concerning concept of ‘‘exercise disease’’?	• ‘‘none’’ (6 respondents) • No response- (74 respondents)
Open question concerning additional notification of measles, cholera, avian influenza through SORMAS?	• ‘‘None’’ (6 respondents) • ‘‘how can I notify through SORMAS’’ (1 respondent) • No response- (73 respondents)

3.8 Supervision and Quality Control

The first weeks of the pilot demonstrated that on site supervision had to be conducted more intensively than anticipated. Problems that were encountered ranged from handling of the mobile devices, network connectivity to understanding the EVD exercise inject. Particularly, the procedures using the exercise injects needed more support. Eventually principal investigators of the project themselves had to travel on site to ensure proper explanations. All the problems encountered during the pilot and the proffered solutions are summarised (Table 7).

Table 7. Challenges of the implementation of phone and web-based application for the surveillance of epidemic-prone diseases and management of outbreak response, Kano and Oyo State, Nigeria, 2015

Challenges	Description	Solution	Recommendation
Registration	• Most of the users did not have email contacts which was necessary for creating accounts with SAP for authentication and registration • SAP saw the large creation of accounts as a spam attack, and deactivated the accounts. • Every login required SAP authentication, which relied on network, limiting access to the apps when connectivity is poor	• email accounts were generated for the users • Contact to SAP team to reactivate accounts • Change of provider suitable for the setting	• Review registration procedure (one-time registration)
User name and password	• User names were too long resulting in typing errors and eventually in locking the app after three failed attempts	• The user name and pass word were simplified, nevertheless typing error occurred • Supervisory visits and calls	• Technical solution should be developed • Unfamiliarity of users with smart phones must be anticipated and taken care of during training
Installation of updates	• Update of apps was necessary after the start of the pilot. Users were not able to update the apps	• For one app, automatic update was implemented • Update of two apps by project supervisors	• All applications must have in-built automatic update function
Data bundles	• Data bundles expired before end of pilot study (use of data for not work-related activities, data provided too small)	• Purchase of new bundles • Supervisory visits	• Technical solution (e.g., configuration of phone) • Consider solutions for sustainability of data bundles costs

Challenges	Description	Solution	Recommendation
Connectivity	• A single network with the best connectivity was initially used per LGA. Connectivity later found to vary by site. • One application was heavy and thus used more data compared to the other. • Internet access for the Web-based app for supervisors	• purchase of sim cards for other networks and data bundles • Three different providers were used • Purchase of modems for supervisor	• Assessment of connectivity to providers by site and not by LGA • App should be modified to require less data
Supervision	• Intense support was necessary for all users • Extra support visits by IT staff was necessary	• Training of supervisors • In Kano, N-STOP staff and in Oyo, NFELTP residents and graduates provided supervision	• When implementing eSurveillance, for the first months, close supervision and support must be included in the planning
Phones	• No power to charge phones • A phone was stolen. However, users had signed a contract during the training to refund in the advent of a loss, if no police report is provided • Phone used for non-work related purposes • Users expressed wish that the forms on the app should be similar to the paper-based forms • User changed phones resulting in inability of the supervisor to assign tasks to the responsible person	• encouragement of users to charge phone whenever possible • Police report provided, phone was replaced • Individual password installed to prevent family members to use the phone, supervision	• Data security must be guaranteed by appropriate access restrictions to app • Use of tracking software in case phone is stolen • Phone should be marked with a surveillance logo which are not removable • The app should have recognizable elements of routine surveillance for the user • Use of solar charger

Challenges	**Description**	**Solution**	**Recommendation**
Training	• Participants had issues such as turning on the data or the phone itself on the field • During training, the Internet access provided by the venue owners was not reliable • In Oyo State, interpretation from English to Yoruba was necessary as participants could not follow during the intense training in English	• NFELTP residents in charge of the different LGAs were encouraged to increase supervision to facilities • Purchase of routers with data bundle, 10 phones could be connected to each router • Project coordinator translated during the training	• Intensive training on the hardware (phone, computer) before introduction to the app must be part of future training programme • Use of interactive training in small groups • One-pager (laminated) detailing steps to enter data • Gain local knowledge in what language should be used during the training
Handling of the apps	• Pilot-related problem, user could select different back-ends for the apps and choose the wrong one	• Supervision visits/calls and correction	• All functions of an app present in a proto-type which are unnecessary for the routine mode must be removed
Data entry	• Selection of wrong categories (e.g., state)	• Supervision visits/calls and correction	• Data entry form must be persona-specific, i.e. data on state and LGA of the officer should be generated automatically
Incentives	• Incentives were paid to motivate participants and supervisors	• Agreement on incentives achieved	• Sustainability needs to be considered

3.9 Discussion

Developing eHealth tools with only minimal input from the end-user can result in “high tech with a low impact” [16]. Involving the stakeholders to support the identification of needs, specification of critical issues for the design and the implementation is key for the success of any IT-tool and especially for a tool to be used within an already existing and acknowledged surveillance system. To ensure acceptability and sustainability for the introduction of any new component of a surveillance system, it is mandatory to identify all relevant stakeholders and to carry them along. The Ministries of Health (National and state level) whose mandate it is to ensure a functional surveillance system were stakeholders.

The two states selected for this pilot study showed enthusiasm for the project and both gave their support all through the study. The integration of the tool into their routine surveillance and their compelling need for prompt reporting of health events and early detection of outbreaks probably contributed to this. This compelling need becomes imperative within the Nigeria context: a large population, vast geographical spread, frequent outbreaks, shortage of surveillance personnel and poor transportation infrastructure. But despite all the aforementioned challenges, the use of technologies had been reported to contribute significantly to the prompt control of EVD outbreak and its containment in Nigeria [17].

The advocacy visits also generated interest among public health officers and appeared to be helpful in securing support in the pilot. Besides technical consideration, pragmatic and strategic implementation issues need to be taken into account when implementing and rolling a system for disease surveillance.

Some technical problems that participants encountered during the training workshops, required additional assistance through telephone support from the programmers or scientific lead abroad. However, some of the challenges during the training also revealed deficiencies in the applications and were used to initiate revisions.

Participants that were recruited for the pilot were the routine surveillance staff at the state, LGA and facility levels. Nevertheless, this proved to be useful, because of the easy adaptability of the expected daily tasks during the pilot to their routine work. Also, not using a different group of personnel, prevented the perception of the advent of another vertical surveillance programme and multiplicity of reporting format, both of which had been identified as some of the problems facing surveillance in Nigeria [18]. Participants showed little difficulties conceptualizing measles and cholera within the SORMAS procedure. In addition to the fact that no avian influenza cases occurred among humans in Nigeria, the time in the curriculum to cover this aspect did not suffice to meet the training need. Likewise, the curriculum time dedicated for EVD management proved to be too short. The training however appeared to have an immediate effect on the knowledge of participants as evidenced by the significant difference in the pre-test and post-test scores (Table 2).

The magnitude of time allotted to the pretesting in this study proved useful. Apart from leading to a change in design by bringing out the need for two additional mobile applications (for the surveillance officer and the hospital informant) which were initially not foreseen, it also allowed for ample assessment and forecasting of the likely problems that were bound to occur on the field during the pilot, hence when this challenges came up, they were not totally unfamiliar and most were resolved and this contributed greatly to the smooth completion of the pilot.

Applications used to transfer surveillance data can be designed for smart phone and are easy to use. The acceptance of phones for surveillance purposes was high in this pilot study and this is a common feature seen in numerous studies in developing countries [19,20]. The data entry per se, into the applications seemed in this study not to be a challenge for the users because all of them had higher education levels. In other studies, where community health care workers or traditional birth attendants were provided with smart phone to transmit data, illiteracy posed problems, but even this could be overcome. Traditional Birth Attendants could not find the menu to see whether a SMS had been sent correctly, but recognized the beep confirming that the SMS was sent [21,22].

Data security and data protection is key when sensitive personal data are transmitted, therefore procedures had to be put into place in this study to ensure data protection. User name and password secured access implied that only a limited number of attempts was possible before the system denies access. The password requirements included the use of capital letters, numbers and symbols from the keyboard but the symbols posed challenges to the users in this pilot study. Looking retrospectively, the authors underestimated the training needs for the hardware and the data security aspect. Data security and the means to ensure data security should have been included in the training module and thorough basic hands-on training was needed for all features of the smart phone needed for doing the job as seen in other studies [23, 24]. The use of username and password unique to each user to access the devices however boosted the confidence of the surveillance personnel about the confidentiality of the data. The choice of the use of locally available hardware for the pilot made a quick replacement and non-interruption of the pilot easy when there was an issue about the theft of one of the devices.

Using mobile devices for surveillance depends on the supporting infrastructure and the coverage of broad bandwidth [25]. Before the start of the field work, the authors assessed the availability and reliability of networks for each LGA. However, there was a need to get for each location within the LGA the best network and to change the network if necessary. The human factor played a role for inability to use the phone even when the network was available.

4. CONCLUSION

mHealth integration into the healthcare system is critical to achieve maximal benefit. Projects have proven to succeed, when they have been adapted to the local context and language, when the government has an existing eHealth strategy and has an interest or willingness to set up a system to integrate mHealth projects and when the project has been developed and implemented by public-private partnerships (e.g., participation of local private service providers, reduced rates) [26]. The majority of mHealth projects are still small scale [19]. There is need to take small scale projects to full scale enabling more rigorous quasi-experimental studies to be undertaken in order to strengthen the evidence base [27].

The SORMAS tool is currently been improved upon and plan is ongoing for a second-phase piloting of SORMAS using the lessons learnt from the Implementation of the first SORMAS pilot. Also, talk is in progress with the Nigerian Ministry of Health and Governments of other West Africa countries to ensure the sustainability of the project and future extensibility into other West Africa countries.

CONSENT

It is not applicable.

ETHICAL APPROVAL

The proposal to implement this pilot study was examined and approved by the Ethical committee of the Department of Planning, Research and Statistics of the Oyo State Ministry of Health with Ref no AD 13/ 479.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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