Leveraging Polio GIS platforms in the African Region for mitigating Covid-19 contact tracing challenges

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Godwin Ubong Akpan[1] PhD, MSc, BEng; Isah Mohammed Bello[2] BSc, MSc; Kebba Touray[1] BSc, MSc; Reuben Ngofa[1] BSc, MSc; Daniel Oyaole[3]; Sylvester Maleghemi[4] MD, MSc; Marie Aimee Babona Nshuti[1] BSc, MSc; Chanda Sangawambi Chikwanda[1] BSc, MPH; Alain Poy[1] BSc, MSc; Franck Fortune Roland Mboussou[1] MD, MPH; Opeayo Ogundiran[1] MD, MPH; Benido Impouma[1] MD, MPH; Richard Mihigo[1] MD, MPH; N'da Konan Michel Yao[1] MD, MPH; Johnson Muluh Ticha[1] MD, MPH; Jude Tuma[5] MSc, PhD; Hani Farouk Abdel Hai Mohammed[1] BENG, MSc, DBA; Nonso Ephraim Ejiofor[1] MD, MBA; Casimir Manengu[1] MD, MPH; Francis Kasolo[1] MD, PhD; Vincent Seaman[6] PhD; Pascal Mkanda[1] MD, MPH

[1]World Health Organization Regional Office of Africa Brazzaville CG
[2]World Health Organization Regional Office of Africa Harare ZW
[3]World Health Organization Nigeria Abuja NG
[4]World Health Organization South Sudan Juba SS
[5]World Health Organization Geneva CH
[6]Bill and Melinda Gates Foundation Seattle US

Corresponding Author:
Godwin Ubong Akpan PhD, MSc, BEng
World Health Organization
Regional Office of Africa
World Health Organization,Regional Office for Africa
Cite Du Djoue ,
Brazzaville
CG

Abstract

Background: The growth of the novel coronavirus 2019 (COVID-19) pandemic in Africa is an urgent public health crisis. Estimated models project over 150,000 deaths and 4,600,000 hospitalizations in the first year of disease in the absence of adequate interventions. Electronic contact tracing, therefore, offers a critical role in decreasing COVID-19 transmission; yet if not conducted properly can rapidly become a bottleneck for synchronized data collection, case detection, and case management. While the continent is currently reporting relatively low COVID-19 cases, digitized contact tracing mechanisms are necessary for standardizing real-time reporting of new chains of infection to quickly reverse growing trends and halt the pandemic.

Objective: The aim of this study is describing an effective contact tracing smartphone app developed with expertise and experience gained from the numerous digital apps that the Polio programme has used to successfully support disease surveillance and immunization assessment in the African Region. A secondary objective is to describe how we leveraged Polio GIS resources to enhance existing contact tracing solutions to be more efficient through the connection to real-time data visualization platforms.

Methods: We propose the use of a hybrid Open Data Kit (ODK) electronic COVID-19 contact registra- tion form that automates contacts and follow-ups. A proof-of-concept form on ODK has been developed that integrates collected contact tracing information from multiple platforms to generate an interactive regional dashboard to monitor the COVID-19 response. Analytics outputs extrapolate key outbreak response indi- cators such as timeliness, completeness and outcomes of contact tracing including new positive cases. This system allows multiple outbreak outputs to be monitored including sources of new infection for immediate response with minimal disruption to existing contact tracing tools.

Results: Standardized electronic registration of COVID-19 contacts and follow-up using ODK has en- hanced monitoring of contact tracing. Countries and communities have increased their capacity to track COVID-19 cases and contacts in the general population quickly based on the onset of signs or symptoms. Registered contacts for contact tracing are matched to their respective cases more efficiently and for con- tacts that can engage in self-reporting, the anonymity of self-reporting. The country-specific results suggest that higher adoption rates of the tools may result in better quality data on the pandemic and elicited better decisions for a response.

Conclusions: Our proposed contact tracing solution which uses ODK based tools on smartphones and visualization bridge systems presents a scalable and easy to implement solution, that collects and aggregates good quality contact data with geographic information that can help make spatial based decisions and preserves privacy while demonstrating the potential to help make better decisions in response to an epidemic or pandemic outbreak. This application has been applied to the current COVID-19 pandemic and can also be used for other epidemics or pandemics in the future, to achieve quality data collection for better decision making.

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Keywords: contact tracing, GIS, COVID-19

1. Introduction

Since the confirmation of the coronavirus in the Chinese city of Wuhan in late December 2019 [1], the disease continues to spread globally. The African region has not been spared [2]. As of 05 July 2020, the continent has recorded 466,300 cases with 11,121 deaths across all countries. Currently the continent with 16.7% of the world's population, accounts for 4% of the global cases and countries are in differing stages of the pandemic [3]. Existing evidence shows that countries which implement public health measures of rapid case identification, testing, isolation, contact tracing and quarantine of contacts early at the onset of outbreaks have suppressed the spread of COVID-19 to low thresholds that do not overwhelm health systems. In these COVID-19 countries excess mortality has been prevented as they are able to deliver quality clinical care and minimize secondary mortality due to other causes through the continuity of essential health services [4]. With no available vaccine or therapeutics, contact tracing, social distancing and quarantine are the only available strategies for controlling the pandemic. In Africa where testing capacity varies greatly, the importance of contact tracing in stopping further progression of COVID-19 cannot be overemphasized.

Contact tracing is a process that involves early case recognition, isolation and tracing of people who have been exposed to a disease [5,6]. It is an essential public health tool for breaking human chains of transmission and has been used extensively in the control of different types of infectious disease outbreaks. FitzGerald et al. conducted a retrospective cross-sectional study on the overall effectiveness of contact tracing on 59% of all reported gonorrhea cases in the United Kingdom. The study revealed that 75% of the traced contacts were infected [7]. From the largest contact tracing exercise conducted in epidemic history on the Ebola outbreak in six countries, between 2014 and 2015, documents the positive predictive value of finding Ebola cases from contacts, [8] to increased detection of new HIV and other sexual transmitted diseases through provider initiated active partner notification, contact tracing has long been used to track new infections from close contacts [6]. Recent studies on the novel COVID-19 used digital contact tracing combined with other measures like social distancing and quarantine that demonstrate a greater effect on the reduction of new cases [9], while Wycliffe and Yixlang showed the importance of contact tracing both on asymptomatic and pre-symptomatic COVID-19, which may be silent drivers of infection in Singapore [10] [11]. Corey et al. comparative studies provide key insights into the effectiveness of individual quarantine versus active monitoring or tracing of contacts for mitigation against COVID-19 from a cost perspective and underscores the need to apply the varying methods depending on the quality of contact tracing in the presiding country [12].

2. Background/Rationale

The implementation of an efficient contact tracing system can vary depending on the place and the type of disease. In the COVID-19 for instance controlling the epidemic with a comprehensive contact tracing system guides which type of intervention is used; self-monitored quarantine in pre-symptomatic and asymptomatic contacts for the duration of the incubation, whereas those with severe active disease may need hospitalization. Additionally, in most scenarios, simple traditional/manual contact tracing methods can be effective in the beginning of the outbreaks when the numbers are low, however large-scale epidemics and pandemics require newer digital contact tracing methods. In highly infectious Pandemics such as COVID-19 that can affect large populations it is pertinent that digital solutions are utilized to effectively locate contacts who have been exposed to patients with a disease, and also, to monitor them consistently, especially those currently on home care and self-isolation. Kretzschmar argued that while contact tracing with mobile apps is important for de-escalation of social distancing measures, timeliness and completeness in contact tracing systems are very important[13].

Numerous types of contact tracing methods have been implemented in different pandemics and endemics, and their effectiveness depends on not just the place of implementation, but also on the tools used. Nonetheless, combining big data analytics with mobile geopositioning methods necessary in large outbreaks and pandemics as shown by Chen et al. to effectively identify 627,386 potential contact-persons of the COVID-19 in Taiwan [14]. The authors concluded that the use of big data analytics combined with efficient contact tracing can help curtail the spread of COVID-19.

Moonan et al. used GIS technology to identify the rate of transmission of tuberculosis and

corresponding incidences [15], while Noremark developed an open-sourced R tool for real-time contact-tracing of disease outbreak in livestock [16]. In a study that combined geographical contacts with social network analysis, contact tracing was used to track two infectious disease outbreaks- SARs and FMD [17]. Data collated by WHO's EPR unit showed that most countries in Africa are struggling to implement efficient contact tracing.

This has greatly increased the number of new community transmitted cases and is looking critical for the continent, as it has been predicted to be the next hotspot for the virus [18]. To effectively curb the problem of efficient contact tracing in Africa, the World health organization (WHO) has sought the support of the Polio program, to build a GIS-enabled tool for contact tracing pertinent to the continent. The AFRO Geospatial Information System (AFRO GIS) center has since 2017, put in place mobile-based solutions to collect health information in near real-time and thus has access to health program implementation and can measure the effectiveness of interventions. The tools provided by the center contributed significantly to the successes recorded with polio certification efforts [19].

In this paper, we present a robust and efficient contact tracking application that can be used across Africa to effectively respond to the COVID-19 outbreak. This application builds on effective tools such as the Open Data Kit (ODK) [20] to collect and manage data in a constrained environment, combined with AFRO Polio- GIS platform [21] in order to locate, identify, monitor and track contacts during the COVID-19 or any other large scale pandemic. The rest of the paper is structured as follows; In the data and methods section, we explain our proposed contact tracing solution including the improvement over existing applications. Next, we talk about the application deployment plan including all tools and material used, then and importantly, we describe our implementation and roll out plan, including pilot location. Lastly, we briefly introduce some resource implications for deploying our solution, and finally, we conclude this paper.

3. Methodology

Proposed Contact Tracing Solution

We considered different scenarios during preliminary discussions with the COVID-19 incident management team managing the regional response at WHO Regional office. It was highlighted that the new solution will leverage existing platforms and will be deployed to fill the current gaps and help address existing challenges with contact tracing. It was noted that while traditional contact tracing can still work in places with few contacts, these approaches will be constrained in countries with many contacts coupled with the impact of lock downs on contact tracing [22]. Consequently, the technical team constituted to review different solutions and recommended the development of a self-reporting contact tracing application. This solution will allow contacts in home-based care, self-isolation and in quarantine centers to provide daily updates on their health condition. In addition, the application will provide an opportunity for these contacts to be able to identify the nearest health facility they can quickly report to if they develop any symptoms of the disease. Leveraging on the success of the AFRO GIS Center and its contribution in the eradication of Polio in the African region, [23] the WHO Epidemic Preparedness and Response (WHO EPR) together with AFRO GIS developed novel tools for immediate field deployment to collect real-time data and monitor the COVID- 19 pandemic in the field. Different technologies were used to develop and integrate this rapid intervention, which included; the ODK technology [24] Stacks via ONA – an open-source tool housed inside the WHO infrastructure primarily for real-time data collection in the field. AGOL [25] and Power BI [26]. Both are data visualization platforms having different use cases for real-time data visualization. APIs were used for data integration and interaction between different systems. Kobo toolbox [27] and dhis2[28] data collection platforms were incorporated for data triangulation and aggregation.

The figure above depicts the architecture deployed for the COVID-19 intervention. It is divided into three components.

1. Data collection component: The architecture is structured to accommodate any data collection platform, giving countries the liberty to use the WHO data collection tool or any data collection tool that suits them such as Kobo Toolbox and DHIS2.
2. API component : This component is responsible for the interoperability and interaction of data between platforms. The APIs link one platform to another.
3. Polio GIS Toolbox and Platform**:** This comprises all the resources developed and deployed within the WHO AFRO infrastructure. It comprises database servers, data visualization tools and platforms.

Deployment of the Self-Reporting Contact Tracking Application

The AFRO GIS center in collaboration with WHO will develop and deploy the COVID-19 Emergency Deployment Tool-Kit on the ODK platform to support contact tracing through self-reporting. In addition,

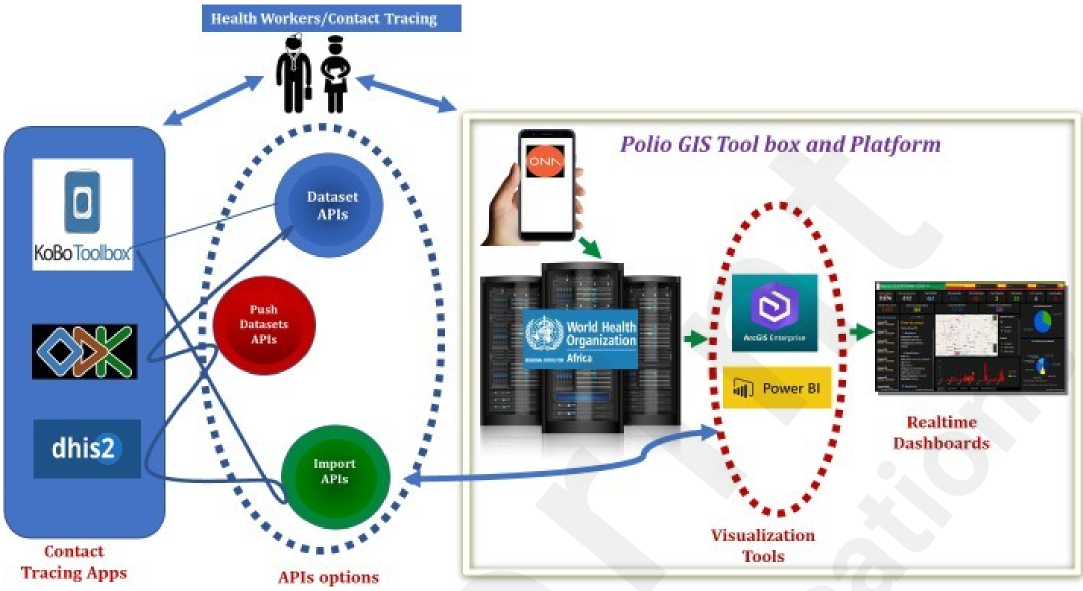

Figure 1: AFRO GIS architecture for COVID-19 intervention

COVID-19 case investigation form will also be developed as recommended by the AFRO COVID-19 team, as this will provide another opportunity to link cases to contacts. These forms are summarized below.

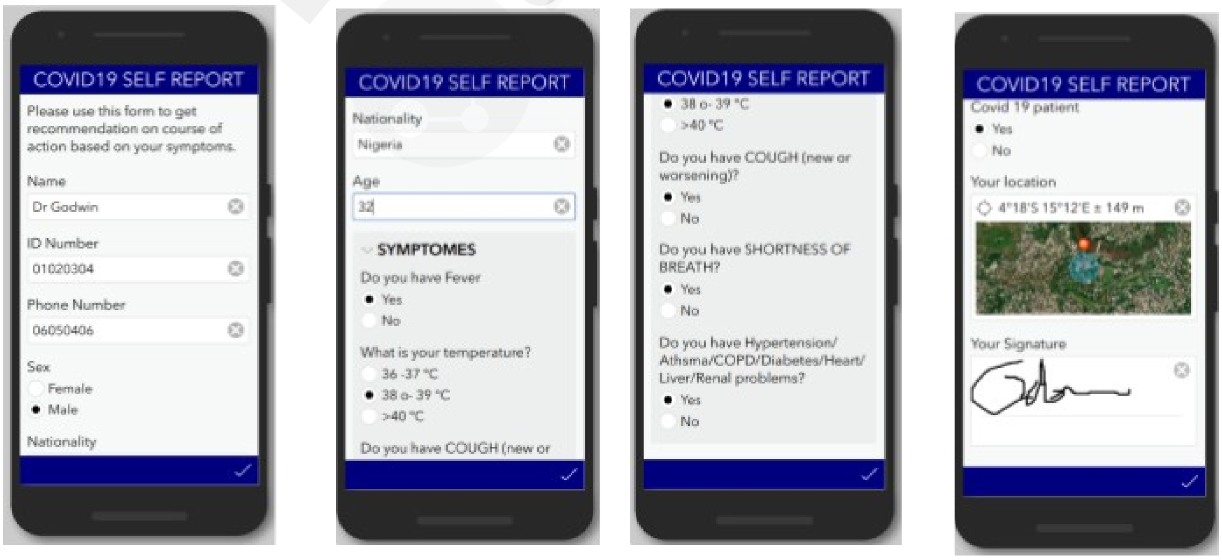

Figure 2: An example of a self-reporting form for use with widespread contacts Follow-up in community transmission mode

1. COVID-19 Case Investigation Form: This form is structured to collect the details and profiles of confirmed/suspected/probable cases. The form can also collect the medical provider’s information, patient information, clinical information, travel history, and final classification of the case. It is important to note

that this form is linked to the case contact form and as such, the case phone number or a concatenation of the country, province , district and case number is used as a unique identifier for referencing and following up .

2. Contact Listing and Follow-up Form: This form is divided into two components; the first component is used to collect the contacts of a confirmed case (contact tracing form), whereas, the second component is used to collect and record the temperature reading of a case contact for 14 days (contact follow-up/self- reporting). This form references the actual case for those contacts that could be linked to a COVID case.

3. Contact Registration: Every contact connected to a case is expected to be registered into the system. A prompt is shown at the beginning of the form that allows for contact registration. The index case's ID number is required in this stage to link the contact to an already existing case in the system (a new contact cannot be recorded without a pre-recorded index case in the system). This displays the records of the index case for confirmation and validation before registering the details of the new contact.

4. Contact Follow-up: After contact registration, the contacts are expected to have a 14-day record update of their temperature and medical condition. There is a prompt at the beginning of the form that allows for contact follow-up (prompts self isolated contacts to submit daily results somehow for the 14 days)

5. Traveler Health Questionnaire and Follow-up Form: This form is divided into two components; the first component is used to collect general information of a traveler entering into the country, whereas, the second component is used to collect and record the temperature reading of the traveler for 14 days (contact follow-up). Note that the follow-up component is linked to the traveler health questionnaire and is referenced using the case phone number of the traveler as the unique identifier.

Database Linkages

The biggest challenge of contact tracing data management is enrolling contacts and performance monitoring of the contact tracing processes [22]. This was overcome by ensuring that the case ID was matched to the contact ID and that the traveler ID is listed on the contact's database during the quarantine period for ease of tracking if the traveler becomes a case. This section describes the linkage system we used to connect the Identity management system of the cases to contacts and travelers while maintaining confidentiality and integrity of the cases and our contacts databases.

Figure 3: AFRO GIS architecture showing forms

Linking the dynamic Cases and Contacts data via XML Form to populate the Cases/Contacts Database

The process hinges around specifying a form data as a media file for another form. Used in conjunction with the pulldata() function, this allows the developer to pull data from other dynamic datasets and surveys (i.e., other forms in the ONA ODK system which are still active and accepting submissions) in the same or different project, similar to pulling data from a pre-loaded CSV file.

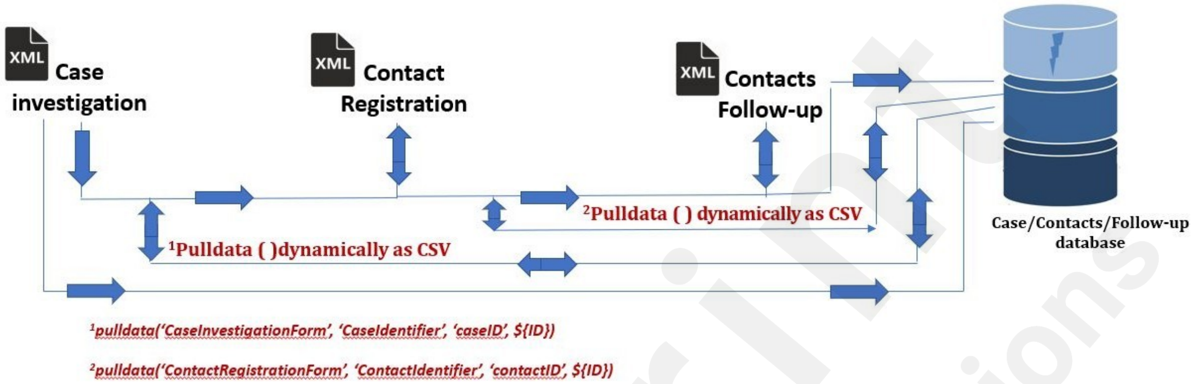

Figure 4: Linking dynamic data via XML files using Pull Functions

On clicking the button "Link Dataset", the changes are saved automatically. The linked dataset appears on forms in the Android device. After dataset linkage to the form, data can be effectively pulled from the linked dataset into the form using the pulldata function under the calculation column. The filename of the linked dataset entered above will be the file name referenced in the pulldata function (i.e., locations). See figure 4 for an illustration of how the pull function and considerations for replicating this in another situation that warrants the use of dynamically pull data from one mobile form through a server to another mobile form.

Performance Monitoring

Evidence-based performance monitoring of contact tracing, surveillance activities and other health interventions by health workers was a key consideration in the repurposing of Polio GIS platforms. A geotracking feature was added to our application to provide geographic evidence of a team's visits to specific contacts. This also ensures that health workers conduct surveillance and other health interventions with the knowledge that their activities are being monitored for accountability.

Visualization and Analysis

A one-stop dashboard that brings data from participating countries into a regional interface for COVID activities was developed using connectors from the databases to ArcGIS and or PowerBI to develop the key performance indicators for the pillars of the COVID-19 response. The dashboard allows the Incident Management team to conduct an integrated and effective response to the pandemic. An example is seen in Figure 5.

Implementation and Rollout Plan

The solution was piloted in Zimbabwe and Benin in April 2020 and then subsequently rolled out in 5 other countries to conduct contact tracing or support other contact tracing data collection expeditions. See Figure 6 for the status of deployments. Since most-98%-countries in the region are familiar with the ODK tools deployment from its use in polio eradication, the COVID-19 contact tracing app is quite easy for countries to deploy and use without training and a steep learning curve. In fact, several additional countries have demonstrated interest following a conference call with the AFRO GIS center in which 15 countries participated. Countries already using similar tools for contact tracing were encouraged to share their APIs with AFRO to enable the GIS center to pull data into the regional platform. However, countries with a high number of contacts have been encouraged to use the self-reporting module for daily contact self-reporting.

Resource Implications

The AFRO GIS Centre, which is currently funded through the polio eradication program, was tasked by

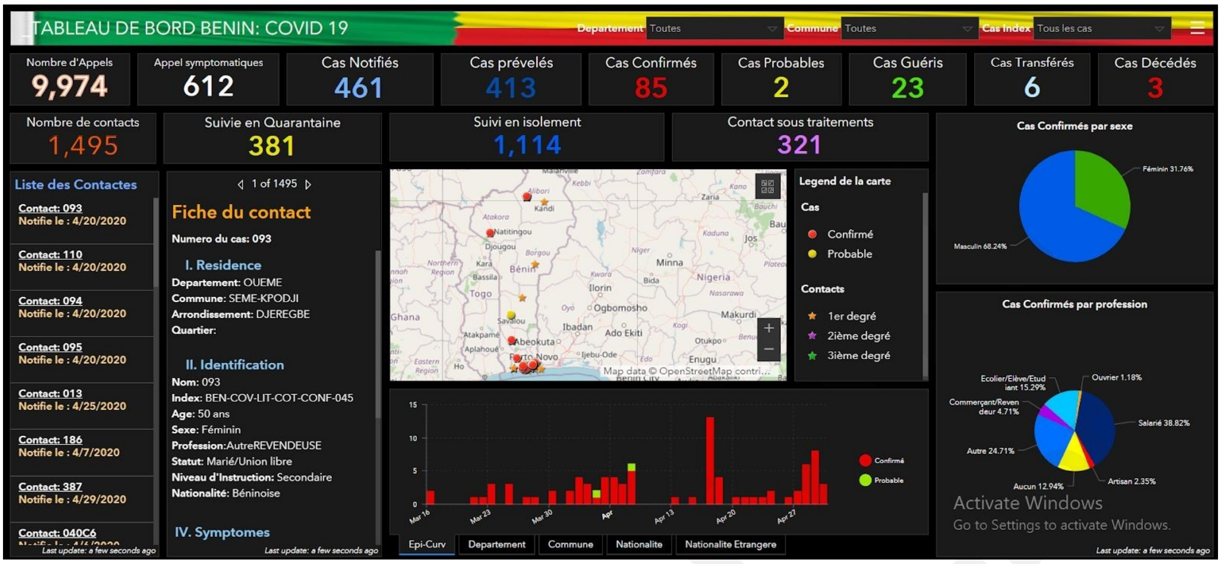

Figure 5: Sample Live dashboard aggregating data from Pillars of the Covid-19 Response

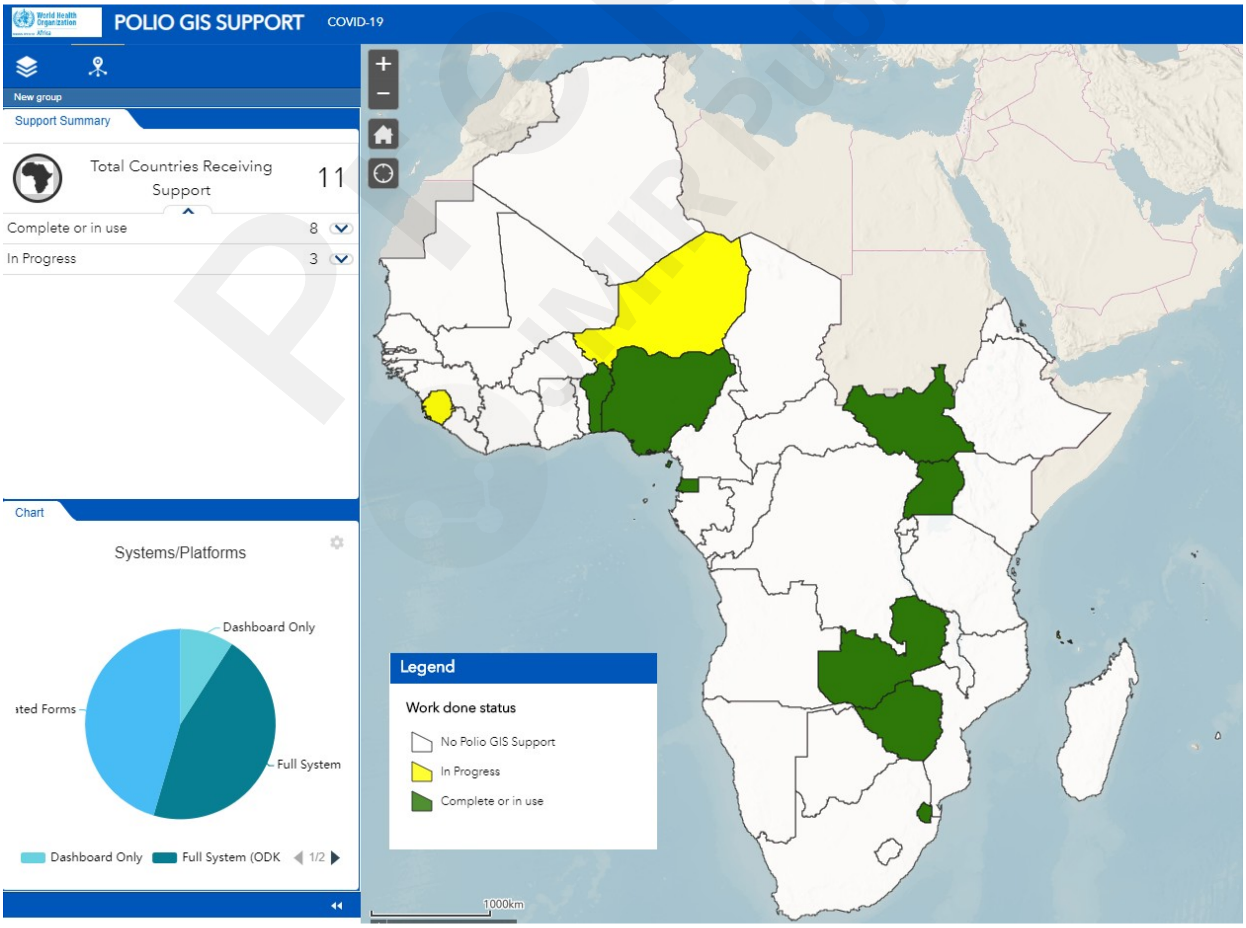

Figure 6: Status of Deployment and Use of the Polio GIS system for contact tracing

the Polio Program Coordinator to support COVID-19 response activities in the region, thus the development, was done at no additional cost to AFRO. Furthermore, the technical staff from the GIS Center working on this initiative were assigned to support the region's response to this pandemic by the Polio Program Coordinator. Countries were informed that implementing this intervention will require additional resources, namely the engagement of local volunteers to follow up on contacts that have not self-reported, and the staff to resolve technical issues at the country level. It is imperative that the startup cost of this electronic contact tracing technique is determined by the cost of phones, data and personnel required. Table 1 summarizes the basic cost of doing so with 1000 contacts

Table 1: Cost of tracing 1000 contacts. cost of hardware (Phones) and data package(MB) for tracing 1000 contacts without logistics considerations which we assume already exist in the traditional contact tracing.

A	Number of Contacts	1000
B=A/100	Number of phones/contact tracers required	100
C=B/5	Number of supervisors	20
D	Daily MB requirements	500
E	Unit cost of data ($)	4
(B*E)+(C*E)	Total daily data cost ($)	480
F	Unit cost of phone ($)	150

4. Conclusion

Evidence from the global pandemic thus far clearly presents three challenges in controlling COVID-19; its lasting pandemic potential, high fatality due to its infectivity and its ability to disrupt health systems. Similarly, in the absence of vaccines and therapeutics, the only available tools for control include contact tracing, social distancing and quarantine. The African Region must, therefore, adopt a variety of methods to minimize the above challenges and adapt the response to the specific needs of each country as the outbreak evolves.

Digital contact tracing will be paramount at some point for every country to stay a step ahead of the virus. The developed applications for contact tracing are not standalone interventions but should be implemented together with social distancing measures and quarantines, depending on the size of the outbreak.

In the region, COVID-19 testing capacity varies widely. Countries with limited testing capacities and large outbreaks will need more advanced comprehensive contact tracing solutions – such as the one described herein - to suppress the virus to lower transmission rates. However, those with smaller outbreaks can use traditional methods with ODK or KOBO collect platforms and simply share their API's with the regional office to ensure all data is available to the Incident Management system.

As countries begin to relax public health lockdowns, traditional and advanced contact tracing methods will be necessary to highlight areas of ongoing transmission- data which is needed not only in their respective countries but also on a regional level to enable a better understanding of the pandemic and optimal decision- making in managing the risks and responses.

If widely adopted in the region this innovation, alongside existing data collection tools (Kobo collect, DHIS2), will help countries respond effectively and efficiently to the pandemic. Other benefits to countries using this tool include real-time monitoring of the epidemic and their response, timeliness and completeness of contact tracing, and staff accountability. These factors are the cornerstone of surveillance during epidemics. It was well-documented during the Ebola outbreak in West Africa 2014 to 2016 that a major contributor fueling the epidemic was the lack of standardized and synchronized contact tracing. Once adopted and implemented a significant decrease in cases was observed across the affected countries, even though at the time, the solutions were not as advanced as they are today.

With the high penetration rate of mobile phones across the African region, mobile-based monitoring of COVID-19 from traditional methods to voluntary self-reporting and remote follow up of contacts will greatly improve the identification of suspected cases and contacts and are important resources to help the region's fight against this debilitating disease. Additionally, the utilization of this tool should reduce the burden on health systems, allowing for the provision of essential health services and minimizing mortalities from COVID-19 and or secondary neglected diseases, that can result from a system overwhelmed by the pandemic.

From the regional perspective, integration of the contact tracing data into one platform provides AFRO with a more accurate method of monitoring country efforts in their response to COVID-19, while guiding public health decisions and the assessment of risk for COVID-19.

Authors contribution

GUA, IMB, KT conceived and designed the process. GUA, IMB, KT, RN, DO, MBN participated in the implementation and iterations. SM, CC, AP, TJ, FFRM, OO, NE, JT and BI contributed to the process data quality control and in the editing of the manuscript. YM, RM, VS, FK and PM provided oversight functions, managed the deployments and provided the project guidance.

Role of the funding source

There was no funding source for these activities as the staff working on this were repurposed for the design and implementation purposes

Conflicts of Interest

We have no conflict of interest in this paper

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