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A software for disease surveillance and outbreak response

Insights from implementing SORMAS in Nigeria and Ghana

A publication in the German Health Practice Collection

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GERMAN HEALTH PRACTICE COLLECTION

Working together to generate and share learning

The German Health Practice Collection (GHPC) is a joint initiative of the German Federal Ministry for Economic Cooperation and Development (BMZ) and its implementing agencies, the *Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH* and KfW Development Bank (KfW), which are known collectively as German Development Cooperation. Since 2004 the Collection has involved experts working in German-supported health and social protection programmes in a collaborative knowledge management process, seeking to identify, document and share knowledge generated during the implementation of programmes around the globe.

From 'good practice' to learning from implementation

In 2015 the Collection shifted its emphasis from trying to capture 'good practice' towards generating new knowledge about the delivery of development interventions. Guided by 2-3 key questions, each case study in the Collection analyses how German programmes and their partner institutions have approached a specific development challenge, how they dealt with difficulties and adapted their approaches accordingly, and what they learned in the process about effective implementation.

Creating ownership through a collaborative process

Since its establishment more than a decade ago, the Collection has helped to catalyse a vibrant community of practice among health and social protection experts through its inclusive and participatory selection and production process.

Each year GIZ and KfW staff from around the world are invited to submit and jointly discuss proposals for experiences they believe should be documented in detail. Through their active participation in the selection process, they help to turn the Collection into a co-creation whose case studies reflect issues and themes which the community regards as worthwhile.

Guided by this assessment of the proposals' merits, BMZ decides which proposals will be documented. Professional writers/researchers with global health and social protection expertise are contracted to develop the case studies in cooperation with programme staff and their partner institutions. Prior to publication, independent peer reviewers who are international experts in their fields review the case studies and comment upon the new insights which have been generated.

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Acronyms and abbreviations

AFENET	African Field Epidemiology Network
API	Application Programming Interface
BMZ	Federal Ministry for Economic Cooperation and Development, Germany
CDC	Centers for Disease Control and Prevention, Atlanta (USA)
DHIS2	District Health Information Software 2
DZIF	<i>Deutsches Zentrum für Infektionsforschung</i> / German Center for Infection Research
ECOWAS	Economic Community of West African States
eIDSR	electronic Integrated Disease Surveillance and Response
GNet	Ghana Community Network Services Limited
GHS	Ghana Health Service
GIZ	<i>Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH</i>
HIE	Health Information Exchange
HL7	Health Level 7 (standards for the electronic exchange of health data)
HTTPS	Hypertext Transfer Protocol Secure
HZI	<i>Helmholtz Zentrum für Infektionsforschung</i> / Helmholtz Centre for Infection Research
IMDB	In-Memory Database
IDSR	Integrated Disease Surveillance and Response
IHR	International Health Regulations (2005)
ISO	International Organization for Standardization
KfW	KfW Development Bank
mSERS	mobile Strengthening Epidemic Response System
NAPHS	National Action Planning for Health Security
NCDC	Nigeria Centre for Disease Control
NCI	National Coordinating Institution
NFELTP	Nigeria Field Epidemiology and Laboratory Training Program
PHEIC	Public Health Emergency of International Concern
REDISSE	Regional Disease Surveillance Systems Enhancement Program
RCDSC	Regional Centre for Disease Surveillance and Control
SMS	Short Message Service (text)
SORMAS	Surveillance, Outbreak Response Management and Analysis System
UHC	Universal Health Coverage
WAHO	West African Health Organisation
WHO	World Health Organization
WHO-AFRO	World Health Organization, Regional Office for Africa

Executive Summary



BOX 1. KEY LEARNINGS

- Insights from implementation of the SORMAS application show that integrating infectious disease surveillance with the management of workflows for outbreak response in a single, comprehensive software platform can strengthen countries' disease control capabilities.
- SORMAS is closely aligned with the Africa-wide Integrated Disease Surveillance and Response (IDSR) strategy, and acts as a business process management tool to strengthen strategy implementation and improve the accuracy and efficiency of workflows.
- Alignment with other digital disease surveillance applications and interoperability with digital health platforms such as DHIS2 will contribute to the development of national digital health ecosystems as these develop.
- Through its modular, flexible architecture, open-source software and its recently acquired status as a Digital Global Good, SORMAS and the countries using it are well positioned to keep pace with the emergence of new diseases, such as COVID-19, as well as with medical and IT innovations.

THE CHALLENGE: WEAK NATIONAL CAPACITIES FOR DISEASE SURVEILLANCE AND OUTBREAK RESPONSE THREATEN GLOBAL HEALTH SECURITY

Global health security is a rising challenge for the 21st century, with the regular emergence of new disease pathogens and the re-emergence of older ones. As the West African Ebola epidemic of 2014-16 showed, infectious disease outbreaks can spread rapidly across borders, resulting in unprecedented social and economic costs and the loss of many lives.

It is essential to strengthen national capacities to comply with the legally binding framework of International Health Regulations (IHR) and to improve implementation of key strategies and approaches, such as the global One Health approach linking human, animal and environmental health, and the Africa-wide Integrated Disease Surveillance and Response (IDSR) strategy, which defines core activities for surveillance and management of outbreaks at country level.

The Ebola epidemic spurred the development of multiple new digital approaches to disease surveillance, the majority aimed at speeding up the transfer of epidemiological data using short message service (SMS) technology on mobile devices, such as cell phones or tablets. However, none of these approaches encompassed all the components and actors involved in a country's disease surveillance and outbreak response strategy, or were able to process the real-time, rapid and multidirectional information flows critical for its success.

The SORMAS (Surveillance, Outbreak Response Management and Analysis System) software, an initiative of the Helmholtz Centre for Infection Research (HZI) in cooperation with Nigeria Centre for Disease Control (NCDC), grew directly out of the experience of tackling Ebola in Nigeria. It is one of few programmes to provide comprehensive disease surveillance and outbreak management functionalities in a single digital platform. Drawing on the experience of implementing SORMAS in Nigeria and its recent introduction in Ghana, this case study aims to answer the question: 'How does SORMAS improve countries' outbreak management and digital health ecosystems?'

THE RESPONSE: A DIGITAL PLATFORM ENHANCES NATIONAL EPIDEMIC PREPAREDNESS AND RESPONSE CAPABILITIES

SORMAS was designed to improve the efficiency and timeliness of disease control measures. What differentiates it from other digital applications in this field is the fact that SORMAS operates as a business process management tool: the entry of a suspected or confirmed case by a health worker at any level of the system automatically triggers a series of actions to ensure that it is managed quickly and efficiently. Multidirectional information flows allow the different actors in the national surveillance and response system to receive information from other network users – such as updates on the status of a patient – and to post new information which is then immediately accessible to all those who need to see it. The platform also sends reminders to users via SMS for tasks that are incomplete or not yet done.

Based on the current and past data held in the platform, algorithms generate early warnings of potential outbreaks when disease cases increase over and above the expected level for a specific place or group of people, over a given period of time. Outbreak response measures are then activated using real-time data and case management functionalities to help manage and control the outbreak.

The flexible, modular design of SORMAS allows for the addition of new diseases and functionalities, which enables the platform to keep pace with the constantly evolving medical and epidemiological state of the art in surveillance and outbreak management. This was demonstrated recently by the rapid activation of a disease surveillance module for the new COVID-19 coronavirus, in response to WHO's declaration of a public health emergency of international concern in January 2020.

SORMAS's transition to open-source software in 2016 was a crucial step for enabling other countries and software developers to use and further improve the platform. As a signatory to the [Digital Investment Principles](#), German Development Cooperation through the *Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH* supported this important transformation. In 2019, SORMAS achieved the status of a Digital Global Good, opening the door to new communities of funders and digital programmers engaged in global health security.

THE RESULTS: WHAT HAS BEEN ACHIEVED

SORMAS has come a long way since the development of the early prototype and its field testing in two Nigerian states in 2014-15: by early 2020, the platform had been introduced in two regions of Ghana, and rolled out to 15 Nigerian states covering a population of some 75 million people – larger by far than the populations of most African countries.

To date, the platform covers more than 12 epidemic-prone, high-priority diseases, including COVID-19, and an 'Emerging Disease X' functionality allows for the immediate inclusion of new diseases as they emerge. The recent introduction of SORMAS in Ghana has demonstrated that, due to its close alignment with Africa's regional surveillance and response strategy ([IDSR](#)), few modifications were required beyond the addition of two new disease modules for anthrax and rabies. The public-private partnership model created to implement SORMAS in Ghana is also demonstrating the feasibility of alternative approaches to SORMAS implementation.

Strong national ownership and leadership of SORMAS by the NCDC has helped to leverage additional funding for the further scale-up of SORMAS from the Nigerian Federal Government, as well as from the European Union, the Centers for Disease Control and Prevention of the United States (CDC Atlanta) and the Bill and Melinda Gates Foundation.

By ensuring interoperability with District Health Information Software 2 ([DHIS2](#)) and alignment with other widely-used digital platforms in the region, such as the [electronic IDSR](#) system and [Epi Info](#), SORMAS will contribute to the development of both national and regional digital health ecosystems as these develop.

Where it all started

In July 2014, as the Ebola outbreak was gathering pace in Liberia, Sierra Leone and Guinea, a Liberian diplomat travelled to Nigeria to attend a regional conference in Calabar, Cross River State. Although he was already acutely unwell, having cared for a sick relative at home, he boarded a flight to Lagos, sparking the outbreak of Ebola in Nigeria (Otu et al., 2018). Unlike in other West African countries, the Nigerian response was swift and effective, helped by the fact that federal and state governments were already on high alert (WHO, 2014a).

A decisive element in this response was the work of a small team of digital specialists assembled at the Ebola Emergency Operations Centre in Lagos, who – literally overnight – developed a mobile application to track and manage suspected Ebola cases, and then moved quickly to train response teams in the field. The deployment of this mobile application facilitated early detection and response, and provided accurate, real-time data for decision-makers – critical for managing outbreaks of epidemic-prone infectious diseases.

The outbreak was largely confined to the cities of Lagos and Port Harcourt. Between the first identified case (known as the ‘index case’) and the last person to be confirmed with the disease in September 2014, a total of 894 people in three states were monitored, with 20 Ebola cases identified, of whom eight tragically died (Shuaib et al., 2014). Given the enormous size and complexity of these cities, as well as Nigerians’ well-known propensity for travel, it was remarkable that the outbreak did not spread further.

THE NEED FOR A SCALABLE APPROACH TO SURVEILLANCE AND RESPONSE

Experts quickly started to think about what might have happened had the outbreak followed a different trajectory. It was clear to those involved that existing disease surveillance and response systems, based on paper forms, phone calls, text messaging, and Excel sheets, were far from adequate (Perscheid et al., 2018). The new mobile application that had been developed as an emergency measure would not be able to handle a larger, more complex outbreak.



→ Health workers in an Ebola-affected area in Nigeria hand over samples for laboratory testing.

The fear that a further epidemic might occur at any time created a sense of urgency to improve the country’s preparedness.

It was at this time that a German epidemiologist at the Nigeria Field Epidemiology and Laboratory Training Programme (NFELTP) called a colleague at the Helmholtz Centre for Infection Research (HZI) in Germany. They discussed the pressing need for a digital application which could handle the multiple interventions required for the effective containment of diseases such as Ebola – namely, routine surveillance, case management and contact tracing, communications and social mobilisation (Tom-Aba et al., 2015).

SORMAS – RAPID PROGRESS IN A SHORT SPACE OF TIME

Fast forward a couple of years, and a new software programme baptised ‘Surveillance, Outbreak Response Management and Analysis System’ (SORMAS) had been developed and tested by a group of Nigerian and German institutions. With funding from the German Federal Ministry for Economic Cooperation and Development (BMZ),

via the *Gesellschaft für Internationale Zusammenarbeit* (GIZ), the early SORMAS prototype was re-programmed as an open-source platform in 2016. In response to major simultaneous disease outbreaks in Nigeria during 2017-18, the platform was quickly adapted to support the management of new diseases, including monkeypox, cerebrospinal meningitis, Lassa fever and measles, and actively rolled out in large parts of the country.

Since this time, the platform has continued to evolve with new functional features and technical capabilities. In 2019, SORMAS achieved the status of a Digital Global Good – that is, an open-source and free-of-charge software, supported by a strong community of developers with funding from multiple sources, and which has been deployed at significant scale in more than one country (Digital Square, 2019). To date, SORMAS has been introduced in 15 of Nigeria’s 36 federal states (including its Federal Capital Territory), covering a population of some 75 million people – larger by far than the populations of most African countries. Much has been achieved in a short space of time, and lessons learned are now being used to inform the adaptation and deployment of SORMAS in Ghana. Professor Gérard Krause, Scientific Lead for SORMAS at Germany’s Helmholtz Centre, explains: ‘Two years ago, I could not have imagined that Nigeria would make such rapid progress in rolling out SORMAS. At HZI, we must respond by pushing even harder for further functional and scientific developments that will improve the platform.’

WHY DIGITAL TECHNOLOGY IS ESSENTIAL FOR GLOBAL HEALTH SECURITY

Global health security is a growing challenge for the 21st century, which is witnessing the emergence of new disease pathogens as well as the re-emergence of older ones (Fährnich et al., 2015). Although non-communicable diseases cause more and more premature deaths across Africa, infectious diseases still account for the largest part of the overall burden of disease (Gouda et al., 2019).

Globalisation and the increasing ease and speed at which people, animals and goods travel across borders make it extremely difficult for individual countries to orchestrate a response to communicable disease outbreaks on their own (Woodward & Smith, 2019). Unlike previous outbreaks, the Ebola epidemic in West Africa rapidly affected three African countries and spread to six other countries on three continents, exacting a huge toll in terms of human lives, and social and economic costs (WHO, 2018).

After the 2014-16 Ebola outbreak, a consensus quickly emerged on the need to improve both preparedness and response activities in the region, particularly in the context of the One Health approach to global health security, which recognises that the health of people is closely connected to the health of animals and the environment



→ Professor Gérard Krause, Scientific Lead for SORMAS at HZI.

(CDC, 2018). As health moves up the global agenda, the central role played by strong and resilient health systems in preparedness and response, as well as in enabling countries to move towards universal health coverage (UHC), has been widely acknowledged and is a cornerstone of Germany’s development cooperation approach.

Global and regional frameworks, such as the legally binding International Health Regulations (IHR) (2005) and the Integrated Disease Surveillance and Response (IDSR) framework in Africa, provide guidance to governments on preventing and responding to epidemics, and enable more effective monitoring of disease outbreaks by regional and international stakeholders such as the West African Health Organisation (WAHO), the World Health Organization (WHO) with its Regional Office for Africa (WHO-AFRO) and the Center for Global Health at the Centers for Disease Control and Prevention in the United States (CDC Atlanta).

As many years of experience with IDSR strategies have shown, paper-based surveillance systems are slow and prone to errors (Njuguna et al., 2019; Sacks et al., 2015), and these challenges are magnified during epidemics, when the speed and precision of the response is paramount. Well-designed mobile and electronic surveillance (eSurveillance) technologies can overcome many of these drawbacks and are characterised by ease of use and rapid availability of real-time data – essential for managing infectious disease outbreaks in hard-to-reach areas (Hall et al., 2014).

Well-designed mobile and electronic surveillance technologies are characterised by ease of use and the rapid availability of real-time data, which is essential for managing infectious disease outbreaks in hard-to-reach areas.

The Ebola epidemic served as a catalyst for the proliferation of new digital programmes focused on improving the early detection of epidemics. The majority of these used SMS technology to create electronic forms that are filled out by health staff at the periphery and submitted to relevant health offices using mobile devices. While the use of SMS has considerably expedited access to data for disease surveillance, this technology cannot handle the operational complexities of both preventing and managing infectious disease outbreaks.

“ The case study aims to answer the question: ‘How does SORMAS improve countries’ outbreak management and digital health ecosystems?’

WHY THIS CASE STUDY?

Like many other of these digital tools, SORMAS did not just focus on Ebola, but grew out of the experience of tackling Ebola in West Africa. However, in contrast to most of them, SORMAS specifically aimed to improve the efficiency and timeliness of broader disease control measures. In addition to supporting disease surveillance and epidemiological analysis at all levels of the public health system, SORMAS aims to strengthen the management of the many complex processes involved in disease control and outbreak response (HZI, 2019; Silenou et al., 2020).

This case study aims to answer the question: ‘How does SORMAS improve countries’ outbreak management and digital health ecosystems?’ Developed through a process of critical reflection with programme partners in Germany, Nigeria and Ghana, including a consultative Stakeholder Workshop in Abuja (Nigeria), the study identifies insights into the development and roll-out of SORMAS that could help to strengthen the digitalisation of disease surveillance and outbreak response in other countries, as well as in the region. It builds on earlier research papers documenting the introduction and evolution of SORMAS (e.g. Adeoye et al., 2017; Fähnrich et al., 2015; Otu et al., 2018; Perscheid et al., 2018; Tom-Aba et al., 2015, 2017, 2018a, 2018b; Silenou et al., 2020 forthcoming).

The study describes how SORMAS works, as well as how the programme evolved to its current status as an open-source, Digital Global Good, and then focuses on key insights that have been gained along the way. An exploration of how the programme can help both to transform a country’s outbreak response capabilities and strengthen the underlying health systems forms an important part of this analysis. The study finishes with a look to the future and consideration of the potential for SORMAS to support a more regional approach to infectious disease control.



→ Participants at the consultative Stakeholder Workshop in Abuja.

What is SORMAS and how does it work?

SORMAS is an open-source, mobile eHealth platform which facilitates the collection, organisation and analysis of real-time data for both disease surveillance and outbreak response, and has been designed specifically to operate in resource-poor settings (HZI, 2019). The SORMAS architecture is closely based on regional and global surveillance strategies and regulatory frameworks, namely, the Africa-wide Integrated Disease Surveillance and Response (IDSR) strategy and the International Health Regulations (IHR) 2005 (see Box 2). It is also aligned with electronic disease surveillance systems in use in the region, such as the [electronic IDSR system \(eIDSR\)](#) and [Epi Info](#).

KEY SORMAS FUNCTIONALITIES

The SORMAS platform is one of very few applications to digitally manage all procedures along the disease surveillance and outbreak response pathways, from the initial detection of cases in the community, through validation and analysis of these cases, to the management of disease outbreaks (Tom-Aba et al., 2018). These procedures encompass the handling of rumours, case management, contact tracing of (suspected) cases and infection prevention, as well as laboratory data management.

A country's IDSR focal points are designated as SORMAS users or 'personas', which means they are able to enter and view data on the platform (see Figure 1). There are 12 different SORMAS user interfaces, each with defined responsibilities within the national IDSR strategy,



BOX 2. REGIONAL AND GLOBAL STRATEGIES FOR SURVEILLANCE AND OUTBREAK RESPONSE

The **Integrated Disease Surveillance and Response (IDSR) framework** is an Africa-wide strategy developed in 1998 by the Africa Regional Office of the World Health Organization (WHO-AFRO) and its partners in response to the re-emergence of large outbreaks of meningitis, cholera, yellow fever and measles. Its objective is to strengthen national public health surveillance and response systems by integrating vertical programmes and making explicit the skills, activities and resources needed at each level of the health system.

In December 2017, 33 of the 47 WHO-AFRO member states had introduced some form of electronic surveillance for IDSR, mostly based on SMS technology (i.e. text messaging), although paper forms remained the dominant mode of reporting at peripheral and intermediate health system levels in all countries (Fall et al., 2019). Only a handful of programmes, including SORMAS, had developed more comprehensive digital IDSR functionalities relevant for the control of infectious diseases (Tom-Aba et al., 2018a).

The **International Health Regulations (IHR)** is a legally binding instrument for addressing global health security and aims to put in place an early warning system for events that can constitute a Public Health Emergency of International Concern (PHEIC) – i.e. one that has the potential to cross borders and threaten people worldwide (Fall et al., 2019; WHO, 2010). IHR defines the core capacities of a national surveillance and response system, helping countries prevent, detect and respond to acute public health risks.

The **National Action Planning for Health Security (NAPHS)** is a country-owned, multi-year planning process supported by the WHO Strategic Partnership for International Health Regulations and Health Security designed to accelerate the implementation of IHR core capacities, and is based on a [One Health](#) for all hazards, whole-of-government approach (WHO 2020).

including hospital informants, laboratory technicians, epidemiologists and public health personnel. Hospital and health facility informants can establish and train their own networks of community informants to ensure that relevant information about potential infectious disease cases reaches them quickly.

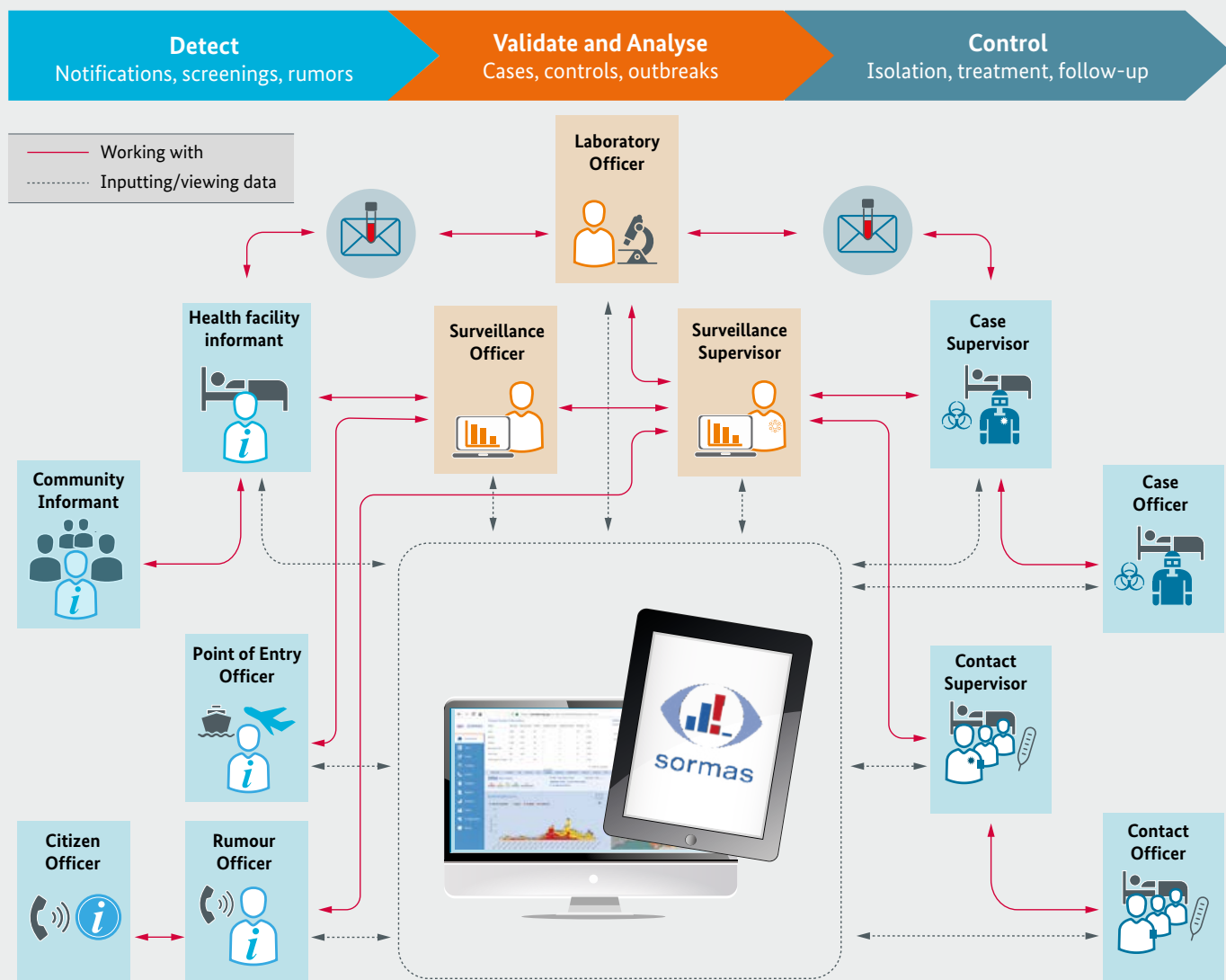
Based on its development in Nigeria and its subsequent adaptation for Ghana, SORMAS now supports more than 12 epidemic-prone, high-priority diseases, including the recent addition of a disease surveillance module for the novel coronavirus (COVID-19), in response to WHO's declaration of a Public Health Emergency of International Concern in January 2020. Figure 2 provides a conceptual illustration of the preventive measures and interventions required for clusters of infectious diseases that are either already included, or planned for inclusion on the SORMAS

platform. A customisable process model ('Emerging Disease X') allows for data entry at country level for any new and unexpected disease.

Data are entered into SORMAS via mobile smartphones, tablets, laptop or desktop computers, depending on the type of user and the level of the health system. The platform is used as a business process management tool, automatically initiating a series of activities and instructions when a suspected or confirmed disease case is entered, such as sending SMS messages to notify the laboratory that a sample is coming in or prompting users to enter complete and timely information on a particular case. As explained by Peter Iko, Community Health Extension Worker and focal point for surveillance at Dei-Dei comprehensive clinic in the Abuja Municipal Area in Nigeria, 'My supervisors can see immediately what I put onto the

➔ **FIGURE 1. SORMAS WORKFLOWS***

* Workflows can differ from country to country



Source: Adapted from graphics by HZI.

“ The platform is a business process management tool, automatically initiating a series of activities and instructions when a suspected or confirmed disease case is entered, such as sending SMS messages to notify the laboratory that a sample is coming in, or prompting users to enter complete and timely information on a particular case.

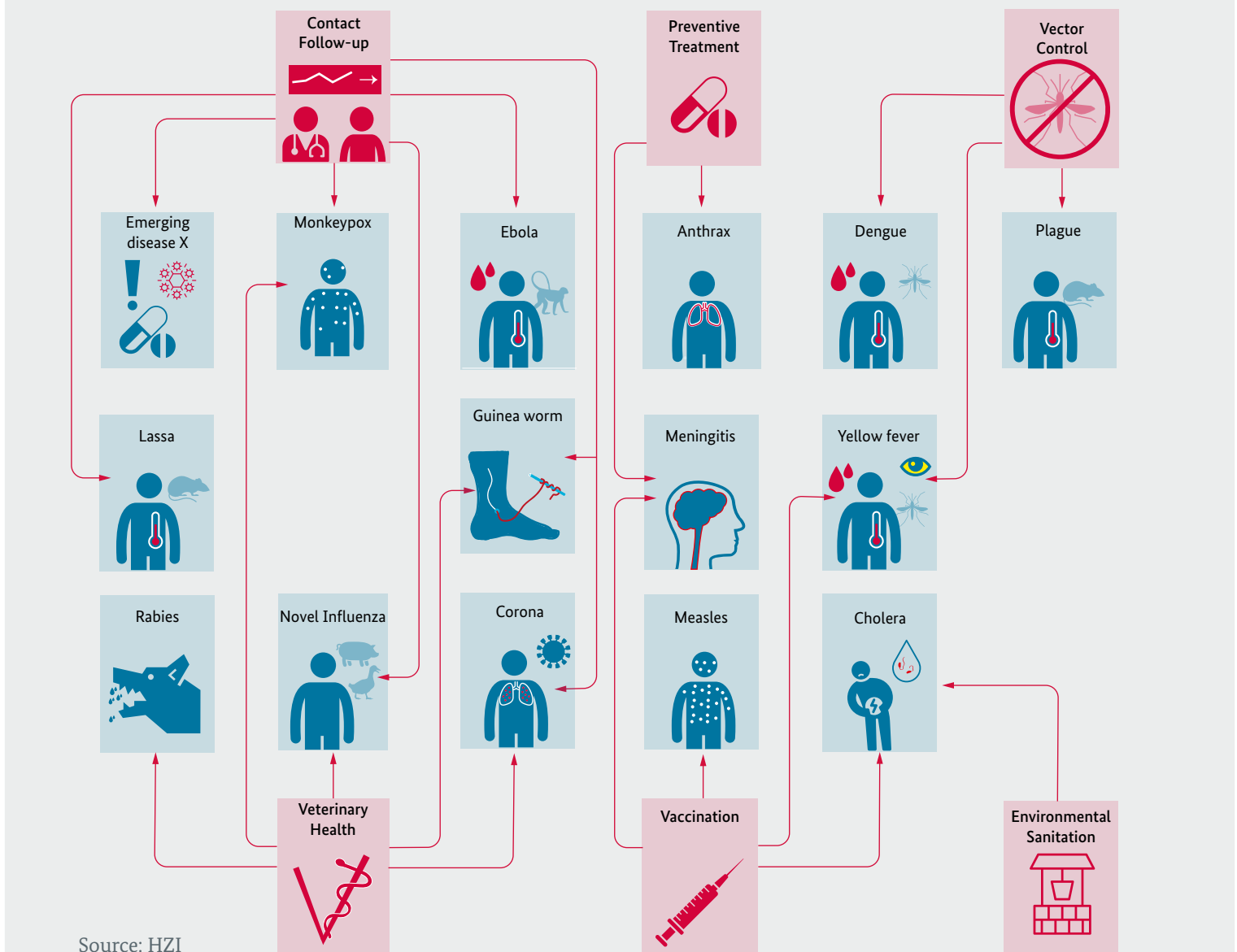
system, so I am inspired to do a good job. I get notifications when I need to enter more information on a particular case and I can see what is happening with samples submitted to the laboratory.’

Algorithms are used to generate early warnings of potential disease outbreaks, based on all the data being entered into the system. Surveillance activities detect increases in the number of disease cases over and above the expected level for a specific place or group of people, over a given

period of time. As needed, the programme automatically activates outbreak response functionalities to process, manage and control the outbreak using real-time data. Since 2019, SORMAS is available in both French and English, with additional programme documentation in the Hausa language. Furthermore, there is a configurable module that can be translated into any language: translators can log into SORMAS and translate key terms which then populate the platform in the chosen language.

Multidirectional information flows enable feedback to lower health system levels, and interactive task management helps to engage SORMAS users in the IDSR processes for which they are responsible. Users at each level can receive information from other users in the network, such as updates on the status of a patient or an instruction to complete a new or existing task. To ensure follow-up of cases and case contacts, the system issues reminders via

→ FIGURE 2. SORMAS PROCESS MODELS FOR DISEASE CONTROL



Source: HZI



➔ Peter Gabriel, District Surveillance and Notification Officer at Bwari Area Council (left) and Peter Iko, Community Health Extension Worker at Dei Dei Comprehensive Clinic, Abuja Municipal Area.

SMS to users, thus improving both compliance with and efficiency of the IDSR processes. According to Peter Gabriel, District Surveillance and Notification Officer at Bwari Area Council in Nigeria, 'SORMAS has come in to really simplify things you know – to expedite action and link up those of us working here with the higher levels. It is quite motivating for us.'

Specially designed dashboards present information tailored to the requirements of different health system actors. For example, central level managers can see at a glance what the public health situation is across the whole country, and dashboards in Emergency Operations Centres play a critical role by facilitating decision-making during epidemics. Mrs Elsie Ilori, IHR National Focal Point for Nigeria and Head of Surveillance and Epidemiology at NCDC, highlights the fact that 'SORMAS dashboards facilitate more strategic decision-making, for both surveillance and outbreak management.'

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SORMAS incorporates indicator-based surveillance, which is the routine collection, analysis and dissemination of standardised information or 'indicators', as well as event-based surveillance, which investigates information about health events that could pose a serious risk to public health. Information on 'events' is drawn from reports, stories and rumours, as well as from other sources, such as social media platforms (WHO, 2014b). This combination of both indicator-based and event-based surveillance is particularly important for countries seeking to improve their early warning systems for outbreaks of infectious diseases.

According to the IHR focal point at the Ghana Health Service (GHS), Dr Michael Adjabeng, this feature addresses an important gap in Ghana's current systems:

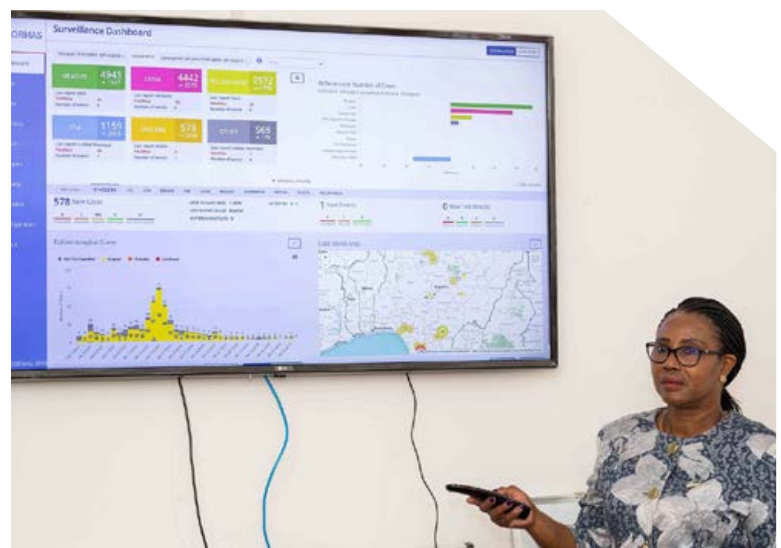
We have been struggling with case-based surveillance, and SORMAS will help to institutionalise an early warning system that incorporates both event-based and community-based surveillance approaches, strengthening our capability to implement IDSR and to meet the requirements of the IHR.

Digital innovation is introducing increasingly sophisticated and complex approaches to the mining of data from social media to facilitate early warning of potential public health emergencies. However, it remains difficult to systematically validate this information prior to activating the correct response (Kostkova, 2015). The Nigeria Centre for Disease Control (NCDC) monitors rumours via a social media monitoring tool called 'Tatafo', and uses SORMAS to cross-check and validate data about potential outbreaks. A more systematic approach to rumour validation is an important area for the future development of the platform.

SORMAS TECHNICAL CHARACTERISTICS

Importantly for low-income countries, SORMAS works both online and offline, and is operable without a continuous supply of electricity. This means that in areas of low internet coverage or with weak or interrupted mobile signal, health staff can continue to use the platform: data are automatically uploaded as soon as a connection is re-established.

All data generated through SORMAS are stored in central servers using a cloud-based approach and In-Memory Database (IMDB) technology to enable countries with limited digital architecture to access data quickly and reliably.



➔ Elsie Ilori, Head of Surveillance and Epidemiology at NCDC, presents data on disease outbreaks from the SORMAS dashboard.

Ownership of the data lies with the National Coordinating Institutions (NCI) for disease surveillance in each country, which in Nigeria is the [Nigeria Centre for Disease Control \(NCDC\)](#), and in Ghana, the [Ghana Health Service \(GHS\)](#).

Given the extremely sensitive and personal nature of health data, SORMAS adheres to the highest data protection and data quality standards (see Box 3), and access to the data is subject to strict national legal agreements.

A modular and flexible architecture ensures that SORMAS can be easily adapted to new national systems and structures. The programme is open-source and free of charge. Source codes and technical specifications are managed and documented on the GitHub website, where software developers can access and alter them.¹ In fact, SORMAS's technical characteristics are constantly evolving, reflecting the changing contexts and requirements of users, wherever the platform is being implemented, as well as the latest digital thinking. The SORMAS roadmap, available on GitHub, is a live document and reflects the planned technical developments for the year ahead.

A modular and flexible architecture ensures that SORMAS can be easily adapted to new national systems and structures.

The speed and agility of open-source software development is an important benefit, deriving in part from light touch and flexible governance (i.e. open-source licensing), encouraging developers to collaborate for the

benefit of the overall community. However, it can also bring challenges when independent modifications to the source codes – called ‘forking’ in the industry – become so extensive that they are no longer compatible with the platform as a whole and users of the modified software can no longer benefit from continuous improvements. To avoid this, HZI acts as the ‘curator’ of the SORMAS system, checking the compatibility of proposed modifications and maintaining the integrity of the overall platform.

Ensuring interoperability is a challenge that goes far beyond the different applications of the SORMAS platform: the rapid increase in digital health applications in Nigeria and Ghana, as in many other countries, calls for the development of national digital health ecosystems which will provide a framework for strengthening interoperability and ensure data protection and security.² In view of this, the SORMAS platform has been designed to facilitate interoperability with key digital health applications, including DHIS2, CDC Atlanta's Epi Info, and eHealth Africa's eIDSR, as well as national surveillance tools. Efforts are now well under way to design the necessary Application Programming Interfaces (APIs) for data exchange between SORMAS and DHIS2.

→ BOX 3. STANDARDS FOR DATA PROTECTION

SORMAS data is encrypted using the latest web standards, including Hypertext Transfer Protocol Secure (HTTPS), which is a highly secure procedure for sending data between a web browser and a website.

The programme adheres to Health Level 7 (HL7) standards, which are a set of international standards for the exchange, integration, sharing, and retrieval of electronic health information (both clinical and administrative data).

SORMAS also conforms to the International Organization for Standardization (ISO) norms, including ISO's Technical Committee 215 on Health Informatics (ISO/TC215), as well as to the interoperable data standards developed by the OpenHIE (Health Information Exchange) community.

For developing interoperability between SORMAS and other digital applications such as DHIS2, Fast Healthcare Interoperability Resources (FHIR) is used, which is an industry standard for exchanging healthcare data between systems. FHIR is free, open, and designed to be quick to learn and implement.

(Cloudflare, 2019; HL7, 2019; HL7, 2020; HZI, 2019)

¹ GitHub is a code-hosting platform facilitating version control and collaboration between programmers who can work together on projects from anywhere in the world.

² The GHPC case study ‘*Digitalising Nepal's health sector*’ describes how this can be done.

From prototype to Global Good: how SORMAS evolved

SORMAS has come a long way since the original prototype was developed in Nigeria in 2014. By December 2019, SORMAS had been introduced and was being implemented in 15 states (including the Federal Capital Territory) and 287 Local Government Areas in Nigeria, and more than 700 users had been trained. Discussions began in mid-2017 on the introduction of SORMAS in Ghana (see Box 5) and, by late 2019, implementation started in the Greater Accra and Upper West regions of the country. This chapter describes important elements in SORMAS's journey from the initial prototype to an open-source Digital Global Good.

DEVELOPING THE SORMAS PROTOTYPE

The programme was developed as a direct consequence of the realisation that the systems in place to respond to the Ebola epidemic in Nigeria in 2014 were inadequate. Delays, backlogs of unreported cases, data errors and a lack of coordination between different reporting systems resulted in the late detection of disease outbreaks and, consequently, the late response and control of public health emergencies. It is thought that the Ebola epidemic went undetected in West Africa for over two months (WHO, 2015).

As in many countries in the region, a number of electronic disease surveillance applications were already in use in Nigeria in 2014–15, including the mobile SMS-based tool mSERS (mobile Strengthening Epidemic Response Systems) and eIDSR. Supported financially and technically by external development partners, these programmes were mostly implemented in a limited geographical area and aimed to improve the efficiency of surveillance activities.³ However, while cheaper and simpler to implement, these programmes lacked the capability to handle the complex processes needed for the control of disease outbreaks, such as case management and the use of algorithms to trigger outbreak response measures.

Since the type of information processed during an outbreak is comparable to that handled for routine surveillance, and given that outbreaks usually occur only sporadically, there was a strong rationale for building a system that could handle both functions (Tom-Aba et al., 2018). The aim for SORMAS was to build a single digital platform with comprehensive disease control management functionalities, which could support real-time rumour management, contact-tracing, case management and surveillance.

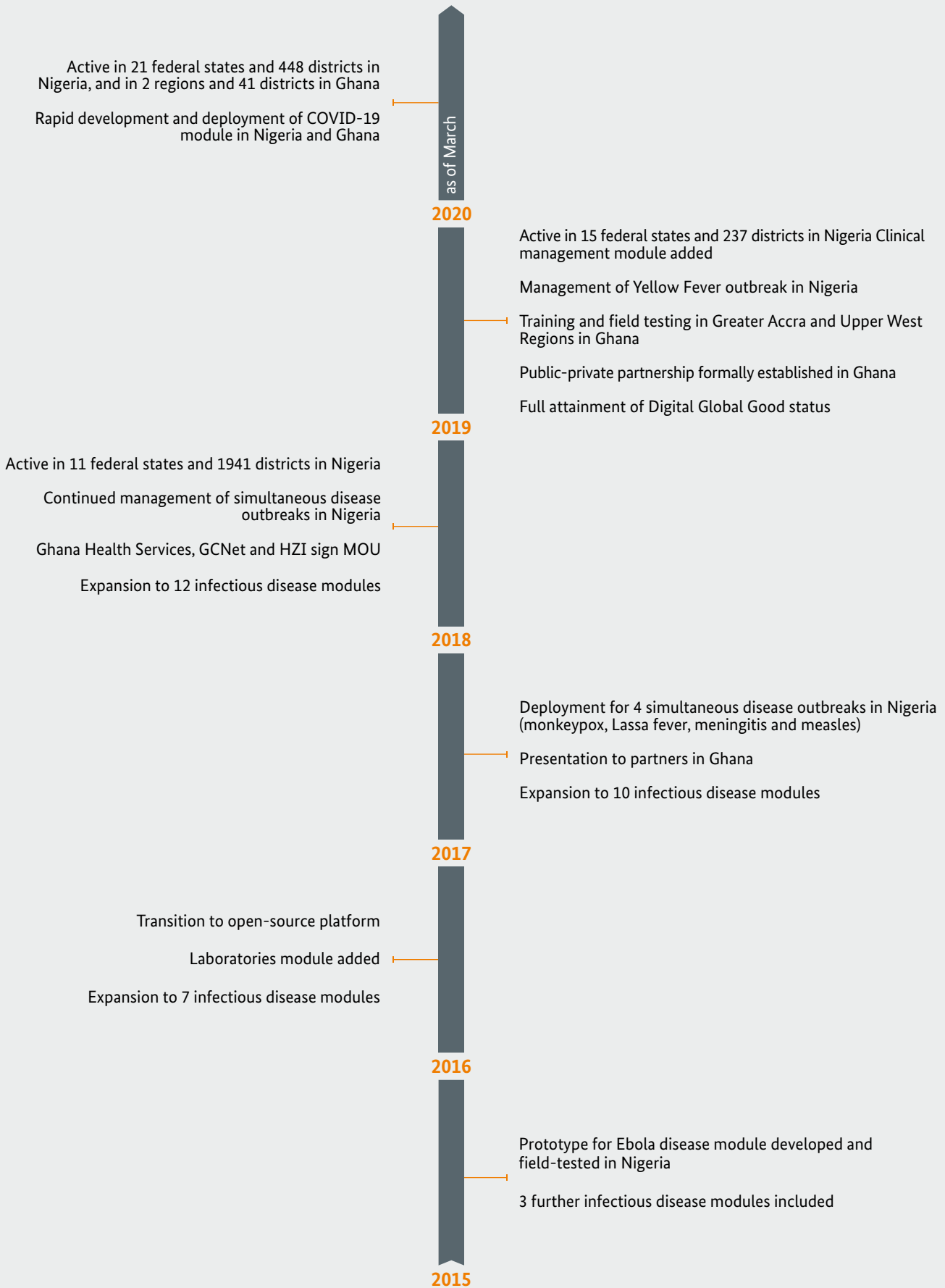
It was clear from the outset that this would require different types of expertise, as well as considerable fund-raising efforts. The first version of the application included financial and technical contributions from six main organisations in three countries, with HZI in the lead, working with NCDC and the [African Field Epidemiology Network \(AFENET\)](#). Early funding was provided by the [German Federal Ministry of Education and Research](#) via the [German Centre for Infection Research \(DZIF\)](#), and important technical contributions were made by a number of other German IT and public health institutions, including [SAP](#), the [Robert Koch Institute](#), the [Bernhard Nocht Institute for Tropical Medicine](#) and the [Hasso Plattner Institute](#) (see Figure 3).

Early in the design process, the Hasso Plattner Institute introduced the 'Design Thinking' methodology with the aim of ensuring that the SORMAS prototype would reflect – as accurately as possible – the implementation and effective management of IDSR processes on the ground. This entailed the systematic analysis of experiences from all those who had been involved in the successful control of Ebola in Nigeria during 2014–16, as well as consultations with public health and IT experts with wide experience of disease surveillance and outbreak response. This approach later supported the deployment of SORMAS in Ghana, involving exchange visits between the teams in Nigeria and Ghana and consultations with future users of the platform.

³ With support from from CDC Atlanta, mSERS has subsequently been scaled up across the whole of Nigeria. However, there are now plans to migrate mSERS to SORMAS during 2020.



FIGURE 3. MILESTONES IN THE EVOLUTION OF SORMAS



During the software development process, a series of pre-tests were organised to assess SORMAS's technical functionality within the Nigerian context, looking at the digital infrastructure, the logic and completeness of SORMAS workflows, and the compatibility of labels and functions with the established surveillance systems. Regular teleconferences between Nigeria and Germany, together with the use of programming 'sprints' (a term borrowed from agile software development) that entail short, intense development cycles, each with a specific goal, enabled an interdisciplinary and iterative approach to SORMAS's development (Adeoye et al., 2017).

After nine months of work, the SORMAS prototype was tested in 84 private and public health institutions in Oyo and Kano states in Nigeria (Ibid.). In June 2015, data were collected and entered on cholera, measles and avian influenza and a simulation of a complex Ebola outbreak was orchestrated to further test the system (see Figure 3).

THE TRANSITION TO OPEN-SOURCE SOFTWARE

A presentation of the SORMAS pilot in 2016 at a meeting in Berlin hosted by the BMZ kickstarted discussions with technical specialists from the Sector Initiative for Digitalisation implemented by GIZ on behalf of BMZ. Recognising SORMAS's potential, as well as the good fit with its own strategy for Digitalisation in Development Cooperation, BMZ commissioned GIZ to support SORMAS's further development.

GIZ support was made conditional upon the transition of SORMAS from a proprietary to an open-source software platform, in line with Germany's strong commitments to the Principles for Digital Development and the Principles of Donor Alignment for Digital Health. Work started in March 2016, and Symeda GmbH came on board to re-programme SORMAS as an open-source platform, based on the many lessons learned during the pilot phase. HZI continued to lead the overall technical development of SORMAS, working principally with NCDC and AFENET.

BOX 4. SORMAS IS RAPIDLY ADAPTED TO ADDRESS FOUR SIMULTANEOUS DISEASE OUTBREAKS IN NIGERIA

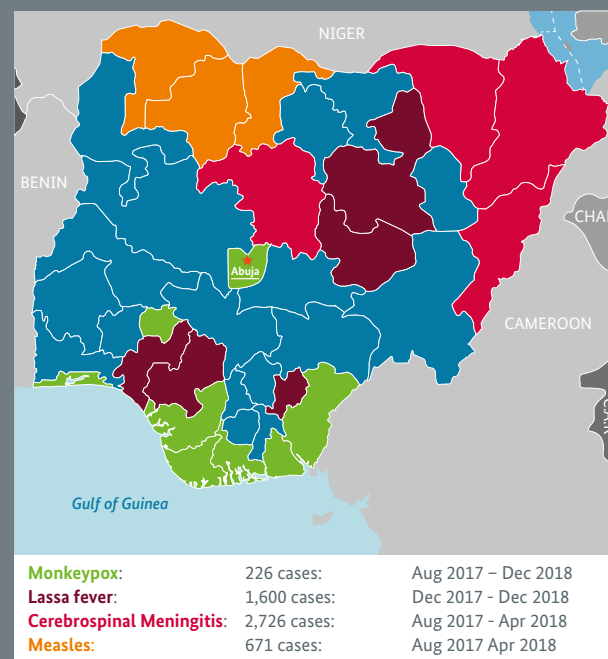
In 2017 when SORMAS was being piloted in Kano State, Nigeria began to experience a number of severe disease outbreaks in different parts of the country. As cases of monkeypox escalated in the south of the country, NCDC's Director General, Dr Chikwe Ihekweazu, asked HZI whether SORMAS could be deployed to support their response. With technical and financial cooperation provided by GIZ (on behalf of BMZ) and DZIF, and technical support from German institutions, led by HZI, a module for monkeypox was developed and SORMAS was swiftly deployed.

Around the same time, outbreaks of meningitis and measles began in the north of Nigeria, while one of the largest outbreaks of Lassa Fever was unrolling in the south. Based on the adaptation and deployment of SORMAS for monkeypox, NCDC asked whether the platform could be further adapted to support the management of these new outbreaks. The German government and HZI provided financial and technical assistance, and the WHO Nigeria office offered additional funding for activities in the north, enabling the team to adapt SORMAS to support the response efforts once again.

Dr Chikwe summed up the benefits of deploying SORMAS: 'Dealing with one outbreak can be difficult. Dealing with four concurrent outbreaks in a large country such as Nigeria presents far greater challenges. The use of SORMAS during 2017-18 enabled us to adopt a more coordinated approach to data collection, analysis and presentation for decision-making across all four diseases, reducing the need for multiple approaches in the context of limited resources.'



→ Dr Chikwe Ihekweazu, Director General of NCDC.



The move to open-source software has put SORMAS on a more sustainable footing, independent from IT companies but at the same time able to benefit from the collective skills and expertise of national, regional and international software developer communities. SORMAS's strong alignment with the Principles for Digital Development – encompassing a modular, scalable and data-driven approach, built around collaborative design principles and detailed user consultations – has been an important success factor in its development.

Through its modular, flexible and scalable approach, and collaborative design principles based on detailed user consultations, SORMAS is well aligned with the Principles for Digital Development.

SORMAS CONTINUES TO EVOLVE AND IS SCALED UP IN NIGERIA

SORMAS has continued to develop both technically and geographically, reflecting the changing requirements of programme users in Nigeria and Ghana, as well as the digital and public health policy and regulatory environments at national, regional and global levels. New user interfaces for public health laboratories and national and regional centres for disease control were added in 2016 and 2017, and new disease modules continue to be added every year (see Figure 3).

In 2017–2018, SORMAS was successfully deployed to support the management of four simultaneous disease outbreaks in Nigeria, including the largest documented human outbreak of the West African strain of the monkeypox virus (see Box 4).

In Nigeria, a comprehensive training programme has been designed in a cascade model with a pool of master trainers at central level and sub-national levels. A growing repository of training materials and formats is being developed and tested, including lectures, training scenarios and instructional cartoon videos, as well as user manuals, troubleshooting guides and tools for supportive supervision and systematic evaluation.⁴

As SORMAS is scaled up in Nigeria and positive results from implementation are increasingly visible, it has attracted new funding partners, including the European Union,⁵ CDC Atlanta and the Bill and Melinda Gates Foundation (see Figure 3). Crucially, the NCDC has proved adept at convincing the Federal Government of Nigeria

to invest in SORMAS, with funds drawn from the World Bank Regional Disease Surveillance Systems Enhancement Program (REDISSE), as well as the Basic Health Care Provision Fund.

SORMAS IS ADOPTED IN GHANA WITH A PUBLIC-PRIVATE PARTNERSHIP APPROACH

In mid-2017, SORMAS came to the attention of stakeholders at a workshop in Ghana where representatives from public health, veterinary and environmental health, the military hospital and the National Health Insurance Authority were gathered to discuss Ghana's One Health approach. SORMAS's appeal to this audience lay in its potential to digitalise the workflows across the IDSR pathway, as well as to introduce the medical and epidemiological state of the art in surveillance and outbreak management. SORMAS Advisor at Ghana Community Network Services (GCNeT), Dr Adriana Ignea, sums up this advantage: 'Just one app for all tasks and processes involved in detecting, analysing and controlling an outbreak – that's what is so special about SORMAS!'

In fact, SORMAS reflects the African IDSR strategy so precisely that only minor modifications were needed for its introduction in Ghana. These included the addition of new disease modules for anthrax and rabies in 2018, adaptations to Ghana's geography and digital infrastructure, and minor changes to case definitions and terminology. Dr Franklin Asiedu-Bekoe, Head of the Disease Surveillance Department at the Ghana Health Service (GHS) is enthusiastic: 'We want SORMAS in our Emergency Operations Centre in order to know what is happening where in the country and when!'



→ Dr Adriana Ignea, SORMAS advisor, with Aba Lokko, Communications and External Relations Manager, GCNeT, Ghana.

⁴ Many of these training materials, as well as a virtual demonstration version of the platform loaded with dummy data, can be accessed via the HZI website: <https://sormasorg.helmholtz-hzi.de/>

⁵ In January 2019, the European Union committed 950,000 Euros in co-financing with BMZ to the GIZ-supported regional programme Support to Pandemic Prevention in the ECOWAS Region.

→ BOX 5. POTENTIAL ADDED VALUE OF THE PPP BETWEEN GHS AND GCNET IN GHANA

Cutting-edge IT expertise: GCNet brings skills and experience in areas that are important for the adaptation and roll-out of SORMAS, including digital programming and coding, extensive data hosting and secure data exchange capabilities, and experience of successfully deploying digital health applications in Ghana. While the Nigeria Centre for Disease Control has gone up a steep ‘digital learning curve’ with support from HZI, the presence of cutting-edge IT capabilities on hand in Ghana may lead to a more efficient handling of requests for technical changes and adaptations for SORMAS. GCNet also has a strong interest in growing the pool of computing graduates with specialist coding skills and is investing in the development of IT capacities.

An entrepreneurial approach: Operating in the commercial sector, GCNet introduces a degree of flexibility and an ability to take financial risks that are more challenging for government institutions, often beset by structural and resource constraints. In Ghana, this capability will be put to use in the negotiation of contracts with telecommunications companies as well as in the facilitation of additional funding streams.

Corporate social responsibility: Financial and in-kind contributions are provided through GCNet’s Corporate Social Responsibility strategy, including the SORMAS ‘hardware’ in the form of pre-programmed android mobile tablets for field staff, training resources for SORMAS users, and dedicated SORMAS servers, as well as free data hosting on GCNet’s own secure servers.

In Ghana, the organisations responsible for the adaptation and rollout of SORMAS are the Ghana Health Service (GHS) and Ghana Community Network Services Limited (GCNet). GHS is an autonomous agency responsible for implementing Ghana’s health policies under the authority of the Minister for Health, while GCNet – incorporated in 2000 – is a public-private partnership (PPP) owned jointly by government agencies (35%) and a group of Ghanaian and Swiss investors (65%). GCNet is a leading organisation in the provision of e-solutions to government, and is responsible for developing and deploying Ghana’s Single Window Platform for Processing Trade Transactions and Customs Clearances, currently used by 41 different government ministries, departments and agencies, and more than 146 domestic tax and customs offices across the country.

Together, GHS and GCNet have formed an innovative PPP to implement SORMAS, which allows each partner to contribute skills and resources in their respective areas of expertise (health services, information technology, research).

Although it is too early to predict the success of the new model, it has been included in this case study to present what could be a promising and different approach for SORMAS implementation – of interest to countries engaged in the digitalisation of their disease surveillance and outbreak response strategies.

For GCNet, investing in SORMAS makes good commercial sense. While the organisation has openly stated that it is not seeking a financial return on its investments, there are clear advantages in obtaining a seat at the ‘digital health table’ – particularly in a country such as Ghana with

strong government support for digital development and robust economic growth. Where critical resources are in short supply (i.e. cutting-edge IT expertise) and a single provider has a large share of the market (i.e. government services), there is a risk that monopoly provision could push up costs for GHS and lead to a less agile environment for SORMAS implementation. Managing PPPs is always challenging, but transparency, accountability, mutual trust and joint steering go a long way towards ensuring success. With a 17-year record of handling government data, a majority of shares in Ghanaian ownership (both private and public) and 99% of its staff Ghanaians, GCNet is dedicated to Ghana’s development and fully accountable to Ghana’s laws.

→ BOX 6. DIGITAL GLOBAL GOODS

Digital Global Goods are IT programmes that are easy to implement and scale up, being adaptable to different countries and contexts, often (although not exclusively) open-source, funded by multiple donors, and supported by a variety of implementers. In addition, they are interoperable across commonly used systems.

The **Digital Global Good maturity model** provides a quick and easy way to understand the level of advancement of different digital health tools. It was developed by Digital Square in collaboration with partners in the global digital health community and assesses the maturity of digital programmes across three dimensions: Global Utility, Community Support; and Software Maturity.

(Digital Square, 2019)

The development, training and deployment of SORMAS in Ghana has moved at a fast pace, enabled by GHS's strong leadership and ownership, integration into Ghana's national structures and systems, and the economies of scope and scale introduced by GCNet. By the end of 2019, 80 disease surveillance staff of GHS had been trained, and tablets had been pre-programmed and handed over to GHS for the roll-out in the Greater Accra and Upper West regions.

SORMAS ACHIEVES 'DIGITAL GLOBAL GOOD' STATUS

SORMAS's transition to open-source software in 2016 set the programme on the pathway to achieving the status of a 'Digital Global Good'. Recognising the opportunities which Digital Global Good status would bring to SORMAS in terms of expert technical contributions and investments, as well as an enhanced profile on the global 'digital stage', HZI began to steer SORMAS towards this goal in 2018 (Tom-Aba et al., 2019) (see Figure 4).

Digital Square guides and coordinates the development of Digital Global Goods in a three-phase approach, starting with submission of a concept note, moving through the collaborative development of the digital tool, and culminating with the review and award of Global Good status according to the Digital Global Good Maturity Model (see Box 6). In July 2019, SORMAS was awarded Global Good status and was included in Digital Square's first ever **Global Goods Guidebook**, which showcases



→ Training for future users of the SORMAS platform in Ghana.

emerging and established Global Goods approved for investment through Digital Square.

Digital Global Goods are particularly important for the development of national digital ecosystems and can serve as a gateway for communities of funders and IT specialists to inject funds and provide programming expertise, supporting national scale-up of programmes. Bringing Global Goods to national scale strengthens data quality and use in countries around the world, which in turn enables health workers and policy-makers to make better evidence-based decisions to improve health outcomes (Digital Square, 2019).

→ FIGURE 4. THE GLOBAL GOODS MATURITY MODEL SCORECARD

		Low	Medium	High
GLOBAL UTILITY	Country Utilization	-1	0	1
	Country Strategy	-1	0	1
	Digital Health Interventions	-1	0	1
	Source Code Accessibility	-1	0	1
	Funding and Revenue	-1	0	1
COMMUNITY SUPPORT	Developer, Contributor and Implementor Community Engagement	-1	0	1
	Community Governance	-1	0	1
	Software Roadmap	-1	0	1
	User Documentation	-1	0	1
	Multi-Lingual Support	-1	0	1
SOFTWARE MATURITY	Technical Documentation	-1	0	1
	Software Productization	-1	0	1
	Interoperability and Data Accessibility	-1	0	1
	Security (PEN Test)	-1	0	1
	Scalability	-1	0	1

Source: Digital Square (2019)

Insights from implementation

This chapter addresses the first part of the study question, namely how SORMAS can improve countries' outbreak management. A number of important insights follow from the process of research and critical reflection on the development of SORMAS, its implementation in Nigeria and adaptation for Ghana. The insights presented here are based on consultations with SORMAS developers and users, project staff, IT and public health experts, and representatives of bilateral and multilateral development partners.

HOW SORMAS STRENGTHENS COUNTRIES' SURVEILLANCE AND RESPONSE CAPACITIES

SORMAS supports countries' IHR compliance. In Nigeria, SORMAS supports IHR compliance by strengthening the country's capacity to monitor and manage infectious disease outbreaks, and by improving the quality of information for reporting to regional and international agencies responsible for monitoring global health security (i.e. WAHO/RCSDC, the Africa Centres for Disease Control and Prevention, WHO). For example, effective surveillance (IHR core capacity 3) requires a functioning early warning system for the rapid detection, assessment, notification and response to all public health risks, whether human, veterinary or environmental. SORMAS algorithms automatically activate outbreak response processes, and concerted efforts to strengthen the One Health approach will be a focus during 2020.

The sustainable scale-up of SORMAS is contingent on its integration into national health system structures and processes and requires strong leadership. The fact that SORMAS so accurately reflects and supports the IDSR processes has been critical to its successful implementation. Robust institutional leadership and ownership by national public health institutes in both Nigeria and Ghana have been essential to the adoption of SORMAS as the national digital IDSR strategy. The Nigeria Centre for Disease Control has strongly promoted the SORMAS platform over other digital IDSR applications and raised funds from a growing number of government and development partners, without which the rapid roll-out of the programme would not have been possible.

SORMAS strengthens accountability and transparency. SORMAS users are more likely to be held accountable for doing their work well, because every action on SORMAS is logged and supervisors can use the platform to manage work processes. By making selected data available to staff at different levels of the health system, and by enabling those working in the field to follow patients through their treatment, SORMAS both enhances transparency and motivates health workers. SORMAS is a business process management tool in that it helps to establish good practices and to increase compliance with IDSR processes as well as with national protocols and standards, particularly at lower levels of the health system.

SORMAS strengthens health systems functioning. Across the processes of disease surveillance and outbreak response, the SORMAS platform links public health and administrative stakeholders at each health system level – from the community up to the centre. Multi-directional information flows strengthen communications between health system actors by making data on patients and their care available in real time throughout the chain of command. For example, in areas where SORMAS has been rolled out in Nigeria, Disease Surveillance and Notification Officers routinely present SORMAS data and analysis at Council and state-level IDSR meetings. This helps to track progress towards public health goals and informs evidence-based decision-making, engaging those working lower in the health system in national level issues and concerns.

INSIGHTS ON THE DEVELOPMENT AND INTRODUCTION OF DIGITAL IDSR PLATFORMS

'Design Thinking' captures the complexities of disease surveillance and control on the ground. The introduction of digital technologies into complex health system processes without adequate consideration of the context, or of the views of those responsible for the processes to be digitalised, has often led to technology-driven approaches that are 'high tech with a low impact' (Van Gemert-Pijnen et al., 2011). Looking back at the evolution of SORMAS, it is

clear that the Design Thinking approach has been critical to the programme's success, ensuring SORMAS accurately reflects the complexities of IDSR strategies as well as health system structures and processes on the ground.

An 'agile' approach to software development builds national programming capacities and enables rapid programme start-up. Software programme development and testing tends to occur in iterative, incremental cycles. The 'agile' development approach allows several development processes to be taken forward simultaneously, while enabling national team members to gain programming and coding skills as these processes advance. This approach builds national programming capacities and results in a product that is both more aligned with the needs of programme users and better suited to the complexities of health systems in low-income countries. It is also 'learning through doing', enabling a more rapid start-up without the lengthy delays associated with finalising every last design detail prior to programme launch.

A modular, flexible system architecture allows rapid adaptation to new diseases. The experience of using SORMAS to support the management of multiple new disease outbreaks in Nigeria in 2017-18 and the recent addition of a surveillance module for the novel coronavirus has demonstrated that the platform can be adapted and deployed at very short notice, which is critical for the successful containment of infectious diseases (Ogunleye et al., 2019). The flexible system architecture enabled SORMAS to improve existing IDSR processes by adding disease modules that were not previously part of Nigeria's IDSR strategy (i.e. monkeypox), and strengthened the One Health approach by incorporating diseases such as anthrax and rabies, bringing together environmental, veterinary and public health stakeholders.

There is a strong rationale for combining disease surveillance and outbreak response functionalities in a single digital platform. Most programmes currently in use are limited to the processing of surveillance reports from the periphery to national surveillance centres, with few dedicated to, or capable of, processing tasks related to outbreak management. Gaps and delays occur – often with serious consequences – when the surveillance and outbreak response systems are separate and cannot talk to each other – which makes little sense given the strong similarities in the information being recorded and analysed. When surveillance and outbreak response functionalities work seamlessly together, as in the SORMAS platform, this optimises national infectious disease control.

Where does SORMAS go from here?

This final chapter looks to the future and addresses the second part of the study question, how SORMAS can support the development of national, and perhaps even regional, digital health ecosystems.

As evidence of its successful deployment in Nigeria and adaptation in Ghana grows, SORMAS is at an important stage in its development. Plans for 2020 include the addition of new disease modules (i.e. polio, Guinea worm, tuberculosis), integration of the mSERS aggregate reporting application into SORMAS, and strengthening the One Health approach by incorporating analysis and reporting functionalities for animal and environmental health. A regional digital health strategy will help to formulate a vision for West Africa, providing direction for new interventions, as well as for the geographical extension of SORMAS.

Such a strategy would help address the fragmentation which plagues digital health systems by fostering interoperability between digital IDSR and other digital health applications, and strengthen the ability of member countries to comply with IHR 2005. Sabine Ablefoni, GIZ Programme Director for the Regional Programme Support to Pandemic Prevention in the ECOWAS Region, believes that 'SORMAS has real potential to improve disease surveillance and outbreak management in the whole West Africa region' and highlights the leading role which WHO's Regional Centre for Surveillance and Disease Control (RCSDC) will play in this process.

In order to promote a more sustainable adoption of digital health solutions at national level, robust digital health policies and strategies aimed at building fully **interoperable digital health ecosystems** are needed, and will help to foster much needed harmonisation between the digital systems supported by different development partners. Ministries of health in Nigeria and Ghana have prioritised SORMAS and are dedicating considerable resources to its scale-up. Both countries have developed National Action Plans for Health Security which call for digital solutions to strengthen IDSR implementation and IHR compliance. In the coming years, those who have worked on SORMAS's introduction and scale-up are well placed to contribute to wider national discussions on such digital health strategies and ecosystems.



→ GIZ Programme Director, Sabine Ablefoni.

SORMAS's status as an open-source Digital Global Good provides a platform for the continued openness and persistence which have characterised its development to date. The adaptation of SORMAS for the Ghanaian context and its introduction via a public-private partnership demonstrate that **different implementation approaches are possible**. As knowledge of SORMAS continues to grow and more countries come on board, new and innovative models are likely to emerge, conceivably involving commercial organisations with an interest in digital development in low-income countries.

International development partners that have supported SORMAS development, including the German government institutions BMZ, DZIF and the Federal Ministry of Education and Research, can play a critical role in sharing lessons more widely, and in contributing relevant experience from other programmes to enrich SORMAS's further growth. It is also important to **strengthen the enabling environment for African involvement in SORMAS's development**, and HZI is doing just this by, for example, tailoring tender processes to make them more accessible and attractive to African programmers. The research, consultations and the learning workshop on which this case study is based are one part of a broader collaborative and informed journey towards a more regional approach to digital disease surveillance and response.

Peer review

Prior to publication each case study in the German Health Practice Collection is reviewed by two independent peer reviewers. The reviewers, who are internationally recognised experts in their fields, are requested to comment on how the case study has answered its guiding questions and whether it has generated new insights into the implementation of the given approach and the development challenge it addresses. The main findings of the peer reviewers who reviewed this case are summarised here.

The SORMAS case study arrives at an opportune time.

The arrival of the novel coronavirus disease (COVID-19) has once again highlighted weak national capacities for disease surveillance and outbreak response – and not only in resource-constrained countries. COVID-19 has served as an urgent wake-up call for improved global and regional coordination of health surveillance, combined with more effective, efficient and timely management of disease outbreaks. The reviewers commented on the timely arrival of the case study, which investigates how SORMAS facilitates just such a combined response at the national level, through a comprehensive, single software platform.

SORMAS is a business process management tool and this is what differentiates it from other digital applications in the field. One reviewer in particular highlighted SORMAS's capability to manage workflows and improve the many processes along the disease surveillance and outbreak response pathways. By guiding users to take the right course of action at the right time and to enter accurate and complete information, and by enabling multi-directional information flows between those working to combat infectious diseases at different health system levels, SORMAS significantly increases the efficiency of national Integrated Disease Surveillance and Response (IDSR) systems.

The case study clearly articulates the **advantages of combining a modular design with a complementary agile design process** – describing the approach that builds large, complex systems such as SORMAS through small, incremental and iterative changes. As one reviewer states, 'This degree of adaptability is highly advantageous in ensuring that country needs are constantly ready to meet the next public health emergency.' This was clearly demonstrated

at the start of the COVID-19 outbreak, when a customised coronavirus module was developed for SORMAS within a two-week period, and was swiftly deployed in both Nigeria and Ghana.

Open-source and Digital Global Good status. Both reviewers highlight the value of open-source coding and the decision to create a user management structure that encourages a growing cadre of digital developers and programmers, as well as epidemiologists and other health specialists, to contribute to its further development and expansion. SORMAS's status as a Digital Global Good facilitates its dissemination into new countries by reducing development costs and lead-in times. The reviewers agree that this case study contributes to this process, with one describing it as 'a convincing and vivid illustration of what diverse actors and stakeholders working together can achieve, generating common knowledge and ownership, building capacities and benefitting from shared experiences.'

The need for the continuous development of SORMAS and similar platforms. The reviewers agreed that SORMAS and platforms like it urgently need to be developed and adapted to the needs of both highly industrialised and lower-income countries. Through wide dissemination of the case study, insights gained from the SORMAS experience could serve as a critical input to the design and implementation of systems to address what is currently for many countries an almost overwhelming situation presented by COVID-19. SORMAS's further development, its roll-out in Nigeria and Ghana and future introduction to other countries should continue to be monitored and analysed for the benefit of all those engaged in strengthening global health security.

Acknowledgements

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Short Videos about SORMAS

A 3-minute video explaining how SORMAS helps countries manage infectious disease outbreaks, published in May 2019: <https://www.youtube.com/watch?v=wSfYlJ1qTZQ>

A series of videos available for training on SORMAS for different cadres as follows:

Surveillance Supervisor: <https://www.youtube.com/watch?v=0vTKZZr8-vg>

Surveillance Officer: <https://www.youtube.com/watch?v=nVJ1k-84d-0&t=65s>

Contact Supervisor: <https://www.youtube.com/watch?v=J7JUdTieEPQ&t=11s>

Contact Officer: https://www.youtube.com/watch?v=YCA_0K46dqE&t=43s

Hospital Informant: <https://www.youtube.com/watch?v=it2ve1ARRbU>

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Friedrich-Ebert-Allee 36
53113 Bonn, Germany
Tel. +49 228 44 60 - 0
Fax +49 228 44 60 - 17 66

German Health Practice Collection
ghpc@giz.de
www.health.bmz.de/good-practices

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WRITER

Corinne Grainger

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Karsten van der Oord

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