Public health pictures

The role of digital surveillance during outbreaks: the Ghana experience from COVID-19 response

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Abstract. Over the years, Ghana has made notable strides in adopting digital approaches to address societal challenges and meet demands. While the health sector, particularly the disease surveillance structure, has embraced digitization to enhance case detection, reporting, analysis, and information dissemination, critical aspects remain to be addressed. Although the Integrated Disease Surveillance and Response (IDSR) structure has experienced remarkable growth in digitization, certain areas require further attention as was observed during the COVID-19 pandemic. Ghana during the COVID-19 pandemic, recognized the importance of leveraging digital technologies to bolster the public health response. To this end, Ghana implemented various digital surveillance tools to combat the pandemic. These included the ‘Surveillance Outbreak Response Management and Analysis System (SORMAS)’, the digitalized health declaration form, ArcGIS Survey123, Talkwalker, ‘Lightwave Health information Management System’ (LHIMS), and the ‘District Health Information Management System (DHIMS)’. These digital systems significantly contributed to the country's success in responding to the COVID-19 pandemic. One key area where digital systems have proved invaluable is in the timely production of daily COVID-19 situational updates. This task would have been arduous and delayed if reliant solely on paper-based forms, which hinder efficient reporting to other levels within the health system. By adopting these digital systems, Ghana has been able to overcome such challenges and provide up-to-date information for making informed public health decisions. This paper attempts to provide an extensive description of the digital systems currently employed to enhance Ghana's paper-based disease surveillance system in the context of its response to COVID-19. The article explores the strengths and challenges or limitations associated with these digital systems for responding to outbreaks, offering valuable lessons that can be learned from their implementation.

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Introduction

The declaration of COVID-19 as a pandemic by the World Health Organization on March 11, 2020, marked a significant turning point in Ghana's response to COVID-19 (1). However, the explanations surrounding the SARS-CoV-2 virus' spread across African countries are riddled with contradictions and uncertainties since its emergence in China. Despite evidence from seroprevalence and post-mortem studies indicating widespread distribution in various African countries, understanding the true extent of the virus's reach has been challenging (2).

Ghana reported its first two confirmed cases on March 12, 2020, originating from Norway and Turkey (3). Within a short period, the virus rapidly spread throughout the country, with Greater Accra and Greater Kumasi becoming the epicentres of the pandemic. Given Ghana's overburdened health delivery system, the government implemented an approach based on three key principles: an ‘all-of-society approach’, an ‘all-of-government approach’, and an ‘emphasis on data and science’ (4). These principles were deemed necessary due to the herculean task of responding to the pandemic, particularly in developing countries like Ghana.

To address the challenges associated with the response to COVID-19, countries worldwide adopted digital technologies to strengthen their public health responses. In 2020, the pandemic response brought about significant innovations as countries developed digital platforms for disease surveillance and monitoring of COVID-19 cases (5). African countries, including Ghana, embraced various systems and technologies to combat the disease, leading to innovative approaches in utilizing digital tools (6).

The rise of the digital revolution has made a profound impact on global health, with smartphone usage becoming prevalent, especially in sub-Saharan Africa (7). This indicates the potential for adopting technology for disease surveillance purposes. Currently, big data, digital, and mobile technologies play a vital role in the field of 'digital epidemiology,' becoming an essential component of infectious disease surveillance systems globally (8). Web-based surveillance tools have become increasingly dominant in many countries, facilitating early outbreak detection and risk assessment for epidemic-prone diseases (9).

Ghana has made significant progress in adopting digital approaches to respond to societal challenges, particularly within the health sector and disease surveillance structure. The coordination of the disease surveillance system through the 'Integrated Disease Surveillance and Response (IDSR)' structure has witnessed substantial growth in digitization. The introduction of numerous digital platforms and applications has improved the timeliness of the case-based surveillance system, which was previously reliant on paper-based forms.

During the COVID-19 response, the digitization of case-based forms played a crucial role in enhancing Ghana's disease surveillance system. Additionally, the utilization of various digital tools and technologies facilitated the transmission of real-time data and effective monitoring of the pandemic's trend in the country. Compared to traditional outbreak response systems without technology, the incorporation of digital surveillance technology significantly facilitated the implementation of COVID-19 response strategies (10,11).

The paper aims to comprehensively examine the application of digital technologies and other advancements in disease prevention, surveillance, and healthcare administration, specifically focusing on the digital surveillance tools utilized in Ghana during the COVID-19 pandemic response. The paper also provides a detailed overview of the technology used in Ghana during the initial phases of the pandemic, with emphasis on the most significant digital systems employed.

Ghana's approach to digital surveillance for COVID-19 pandemic response. Ghana's adoption of electronic or digital platforms aimed to enhance case detection of emerging infectious diseases, including COVID-19, warrants critical analysis. Among the digital systems deployed during the pandemic, such as the 'Surveillance Outbreak Response Management and Analysis System (SORMAS)', the digitized COVID-19 dashboard, the electronic Health Declaration Form (eHDF), ArcGIS Survey123, Talkwalker, the Lightwave Health Information System (LHIMS), and the 'District Health Information Management System (DHIMS)', it is crucial to evaluate their actual impact on the country's response to the pandemic.

While these digital systems have been touted as contributors to Ghana's success story in combating COVID-19, a critical examination of their effectiveness is necessary. Claims of simultaneous reporting and monitoring of COVID-19 cases and other priority diseases through digital disease surveillance in Ghana need to be assessed for their reliability and accuracy.

The following sessions will delve into a detailed description of the various digital platforms employed in Ghana's Emergency Operation Centre (EOC) during the pandemic. By critically analysing their utilization and outcomes, a more comprehensive understanding of their effectiveness and impact on the country's response efforts can be gained.

Surveillance outbreak response management analysis system. The utilization of a conventional surveillance system, reliant on paper-based forms that relies on manual transfer into databases of the 'Integrated Disease Surveillance and Response System (IDSR)' framework, in Ghana's outbreak investigation necessitates critical examination. The reliance on outdated and time-consuming manual processes raises concerns about the system's effectiveness and efficiency, particularly in the context of a rapidly evolving pandemic like COVID-19 (12,13).

Although a pilot phase of the SORMAS was conducted in two regions of Ghana before the outbreak, focusing on meningitis and cholera, its implementation as the primary tool for public health surveillance in response to COVID-19 needs careful assessment. The adjustment of SORMAS to include a COVID-19 module demonstrates a reactive approach rather than a proactive one, indicating a lack of preparedness for a global pandemic of this scale (14).

The decision to adopt SORMAS was driven by the challenges faced in updating and verifying case information, incorporating laboratory results, and overseeing contact tracing using the traditional system, as the country experienced a surge in cases. In May 2020, Ghana rolled out the SORMAS across the country in response to the pandemic. SORMAS replaced ArcGIS Survey 123 as a comprehensive system for surveillance and data management during the pandemic response. However, the extent to which SORMAS effectively addressed these challenges and improved the timeliness and accuracy of disease control measures requires critical scrutiny and further studies.

SORMAS, marketed as 'an open-source mobile and web application software', claims to enhance the efficiency and timeliness of disease control measures. The depicted workflow in Fig. 1 presents an idealized process, but its real-world effectiveness and adherence to standard protocols and guidelines require careful examination.

While SORMAS allows health workers to notify health departments of new cases, detect outbreaks, and manage response efforts, the practical implementation and user experience may differ significantly from the depicted system. The reliability and accuracy of the data entered into the system, the integration of laboratory results, and the real-time monitoring and reporting features must be critically evaluated to determine the system's true effectiveness.

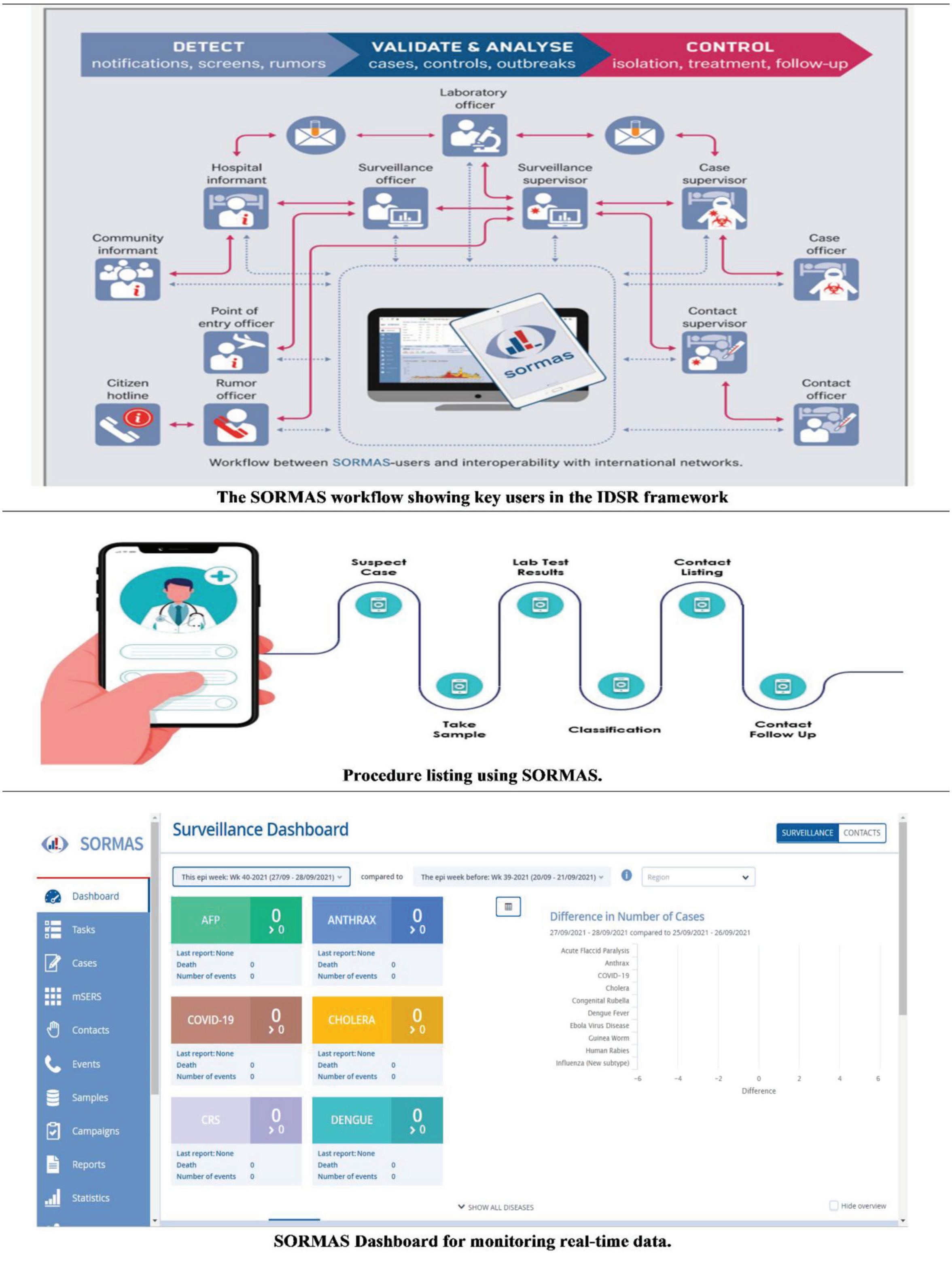

Figure 1. SORMAS workflow, procedure, and dashboard.

The workflow of the system, as depicted in Fig. 1, demonstrates the process of detecting, validating, analysing, and implementing control actions for cases. The officers at various health facilities report all cases, which are then entered into the system and assigned to specific laboratories. Once the laboratories receive the samples and have the results ready, the laboratory officers update the results online, allowing officers at different levels to access real-time information. Additionally, the automatically updated dashboard (Fig. 1) provides insights into the number of reported cases, along with an overview of other diseases. This feature enables a comparison of cases between the current and previous weeks. The Emergency Operation Centre (EOC) officers monitor real-time data,

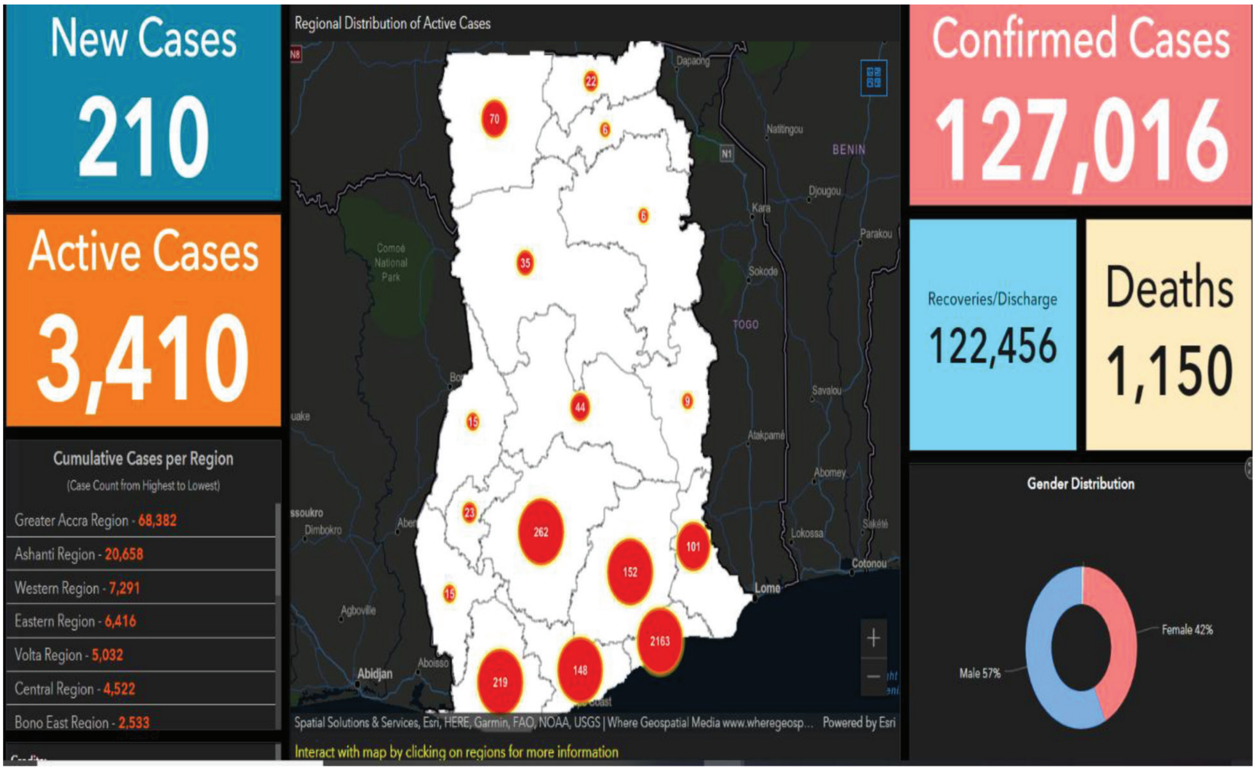

Figure 2. Ghana's COVID-19 dashboard introduced during the COVID-19 pandemic.

generate situational reports, and utilize the data to inform decision-making. Moreover, SORMAS facilitates the tracking of contacts for positive COVID-19 cases, as illustrated in Fig. 1. The process entails listing and following up on contacts using the system.

SORMAS represents a system characterized by certain advantages and drawbacks. Some of its strengths are its interoperability, which allows it to seamlessly integrate with other health systems and ensure smooth data sharing and system communication, its open-source nature, which enables continuous upgrades and improvements through contributions from the developer community, its real-time data, which ensures users across different levels can access up-to-date information and aid swift decision-making, its robust access control mechanisms, which ensure users only access and edit data they are authorized to, and its easy access to detailed records of priority diseases, which enables rapid response when needed. However, it also has some weaknesses, such as its many features, which can be overwhelming for new users and even some of the existing users, its web interface, which is not very intuitive and requires repeated training, its analytics capabilities, which may be insufficient for complex statistical analyses, and its inadequate automated data quality checks, which relies on users to ensure accuracy, consistency, and completeness.

While SORMAS may offer potential benefits, its actual performance and impact on Ghana's response to the COVID-19 pandemic was exceptional but needs further investigation. The examination should go beyond the idealized depictions and explore the system's practical implementation, user experience, data accuracy, and its overall contribution to disease surveillance and control measures.

Ghana COVID-19 dashboard. The communication of results and findings to the public is crucial during outbreaks as part of an effective response strategy. To facilitate this, data dashboards have been extensively utilized during the COVID-19 pandemic to visualize real-time public health data (15). However, the initial approach taken in Ghana, where results were announced exclusively through press conferences by the Minister of Health and other officials from the Ghana Health Service before media houses could publish updates, resulted in an information gap between health officials and the general population. This approach hindered timely and widespread access to crucial information, creating a communication barrier (16).

Recognizing the need to bridge this information gap, the officials of the Emergency Operation Centre of the Ghana Health Service and their partners introduced a dashboard specifically designed for the public, shifting the target audience from policy makers (Fig. 3). This alteration aimed to ensure that confirmed cases, deaths, and testing figures were made known to both the public and decision-makers, facilitating informed public health action (16).

The confirmed cases, deaths, and testing figures were made known to the public and decision-makers for public health action. Ghana introduced the COVID-19 dashboard for effective dissemination of vital data and information to the public a few months after recording COVID-19 cases.

The Ghana COVID-19 dashboard is updated through a rigorous process that involves collecting, validating, processing, reviewing, and uploading the latest information from multiple sources. These sources include SORMAS and the electronic Health Declaration Form (e-HDF), which provide data on new cases, recoveries, and deaths. The head of the COVID-19 desk

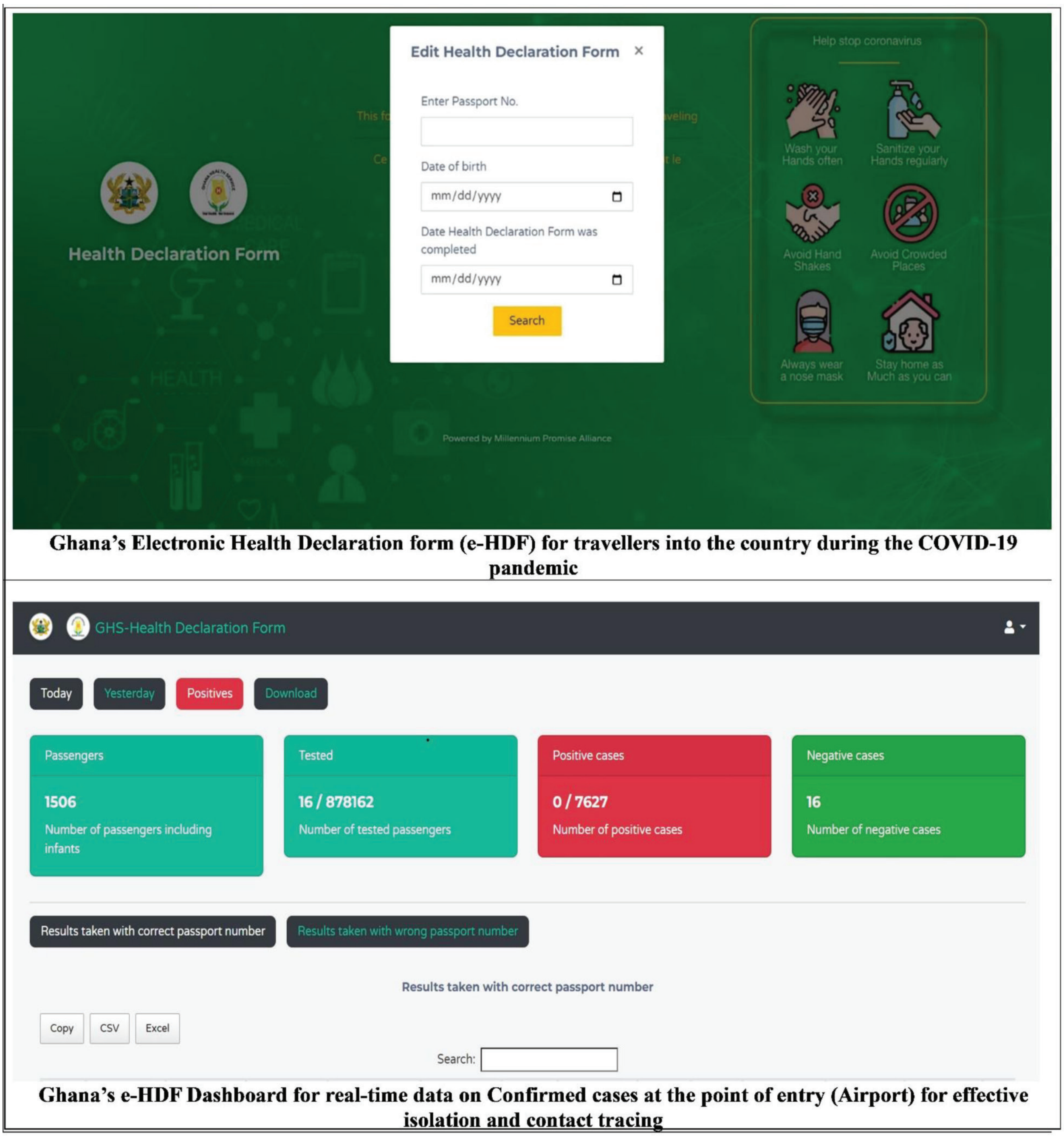

Figure 3. e-HDF form and dashboard.

performs the initial verification of the data, followed by skilled data analysts who process and visually represent the data using graphs, charts, and maps for clarity. Next, various experts and authorities in the Disease Surveillance Department of GHS review the processed information to ensure accuracy before proceeding. Finally, the Public Health/Disease Surveillance IT team prepares the data in a format suitable for the website and manages the upload process. The updated dashboard serves as a valuable resource for citizens, researchers, and policymakers.

The COVID-19 dashboard on the Ghana Health Service website has some strengths and weaknesses. Among its strengths are providing regional case count breakdowns for more localized insights, supplying key data to researchers, policymakers, and other stakeholders to enable informed pandemic response decisions, and keeping the public updated on the COVID situation to promote appropriate behaviours. However, it also has some weaknesses, such as not having real-time data, which could cause discrepancies between reported and actual cases, and a lack of direct communication with other health information systems like SORMAS and DHIMS, which could lead to potential delays and inefficiencies.

The Dashboard also helped in understanding the evolution of cases from different regions and perspectives. It is worth noting that Ghana introduced the COVID-19 dashboard few months after recording COVID-19 cases, suggesting a delayed response to the interactive communication needs of the population. The effectiveness of the dashboard in effectively disseminating vital data and information to the public should be critically evaluated. Additionally, its role in enhancing the understanding of case evolution across different regions and perspectives needs to be assessed.

Electronic health declaration form. The e-Health Declaration Form is an online system designed for travellers entering Ghana to provide their biodata before arrival in the country. The Ghana Health Service, the Ministry of Health, and other partners launched the website to facilitate the completion of the health declaration form, generate travel certificates, and provide the latest travel instructions before entry into Ghana (Fig. 3).

Previously, officials faced difficulties in tracing contacts of individuals who had travelled with confirmed COVID-19 cases due to the large number of paper forms that were filled out daily. Since many index cases in Sub-Saharan Africa were travellers, ensuring the quality and completeness of data at the point of entry was crucial (17). Therefore, the introduction of the e-Health Declaration Form (e-HDF) significantly reduced the need for human interaction at entry points and allowed travellers ample time to provide their details before arriving in the country (Fig. 3).

Through the e-HDF system, traveller data was received in real-time, and the results were updated at the airport using the same system. Laboratory results generated at the point of entry were displayed in real-time on a dashboard at the country's Emergency Operation Centre. This provided valuable information on the level of COVID-19 importation, enabling necessary public health actions to be taken promptly.

The e-Health Declaration Form (e-HDF) which replaced the paper forms and manual data entry with an online form that travellers can fill out before arriving at their destination. It has some benefits, such as saving time, resources, and environmental impact, enhancing the accuracy and completeness of the data and facilitating contact tracing and follow-up of travellers, and being a user-friendly and secure system that can be accessed through any device with internet connection. However, it also has some drawbacks, such as facing technical or operational challenges that can affect its functionality and reliability, depending on the availability and reliability of internet connectivity can be a challenge in some remote or low-resource settings or during network disruptions, and not capturing all aspects of the traveller's health status.

Talkwalker. Talkwalker is a powerful digital tool utilized for social media scanning, allowing users to search for specific information across various online platforms such as social media, blogs, and news organizations. It offers customizable search options, enabling users to define date ranges and select specific sources for scanning (18).

During pandemics, effectively managing the spread of misinformation, known as an 'infodemic,' is crucial for an efficient response. Hence, the adoption of Talkwalker at the Emergency Operations Centre (EOC) to gather up-to-date information on public perceptions and opinions from the internet was considered a commendable approach. At the EOC, Talkwalker was employed to scan for COVID-19-related posts specifically within Ghana, encompassing websites and various social media platforms (19).

The information obtained through Talkwalker includes the identification of major themes being discussed globally and in Ghana, based on customized search criteria. These themes helped gain insights into current discussions and aided in tailoring COVID-19 information to effectively reach the public. Additionally, the tool monitored the trending hashtags for specific periods on a global and Ghanaian scale. This monitoring facilitated a better understanding of the dynamics and trends within online discussions.

Furthermore, Talkwalker can provide demographic insights by analysing the engagement of individuals on social media platforms. This analysis allows for a better understanding of the target audience and their characteristics (Fig. 4). Additionally, the sentiment analysis feature of the tool enables the identification of negative and positive posts regarding interventions or public health actions (Fig. 4). This includes the detection of rumours and misinformation circulating on the internet. The tool also helps in determining the reach of specific COVID-19 information and the level of engagement from the public (19).

Talkwalker is a tool that provides comprehensive insights into public health sentiments by monitoring diverse platforms such as social media, news, forums, etc. It has several advantages, such as enabling swift reactions to emerging trends and concerns by providing real-time monitoring, simplifying the understanding of patterns and trends by using visual data representations, quantifying positive, negative, and neutral opinions behind posts by using sentiment analysis, and keeping stakeholders updated on relevant developments by sending alerts. However, it also faces some challenges, such as requiring dedicated personnel to filter through and identify relevant information from large data volumes, needing manual review to eliminate irrelevant posts that are flagged due to keyword matches as false positives, demanding specialized training to ensure optimal use of complex features and settings, covering only a majority of platforms and excluding some niche or local platforms that are outside Talk walker's scope such as online news portals, and sometimes misinterpreting sarcasm and complex emotions due to bias in sentiment analysis.

Overall, Talkwalker proved to be an invaluable asset at the EOC, providing comprehensive monitoring of social media and online platforms to effectively track public sentiments, address misinformation, and gauge the impact of COVID-19-related information dissemination.

Global epidemic prevention platform-Ghana. The Global Epidemic Prevention Platform (GEPP) is an open-access application developed by Korea Technology (KT) and introduced in Ghana in 2018 to aid in the prevention of disease transmission during epidemics. At the time COVID-19 was recorded in Ghana, the system was still undergoing a pilot study using other priority diseases. However, some disease control and surveillance officers from the Greater Accra region, which was the epicentre of the pandemic, have received training on the potential of the system to complement other available systems for the pandemic response.

The application serves as a tool for the public, allowing them to download and install it on their devices. Its primary function is to provide disease alerts to users when a particular area has reported an infectious disease or is experiencing an outbreak. In such cases, the application sends an emergency push message to users,

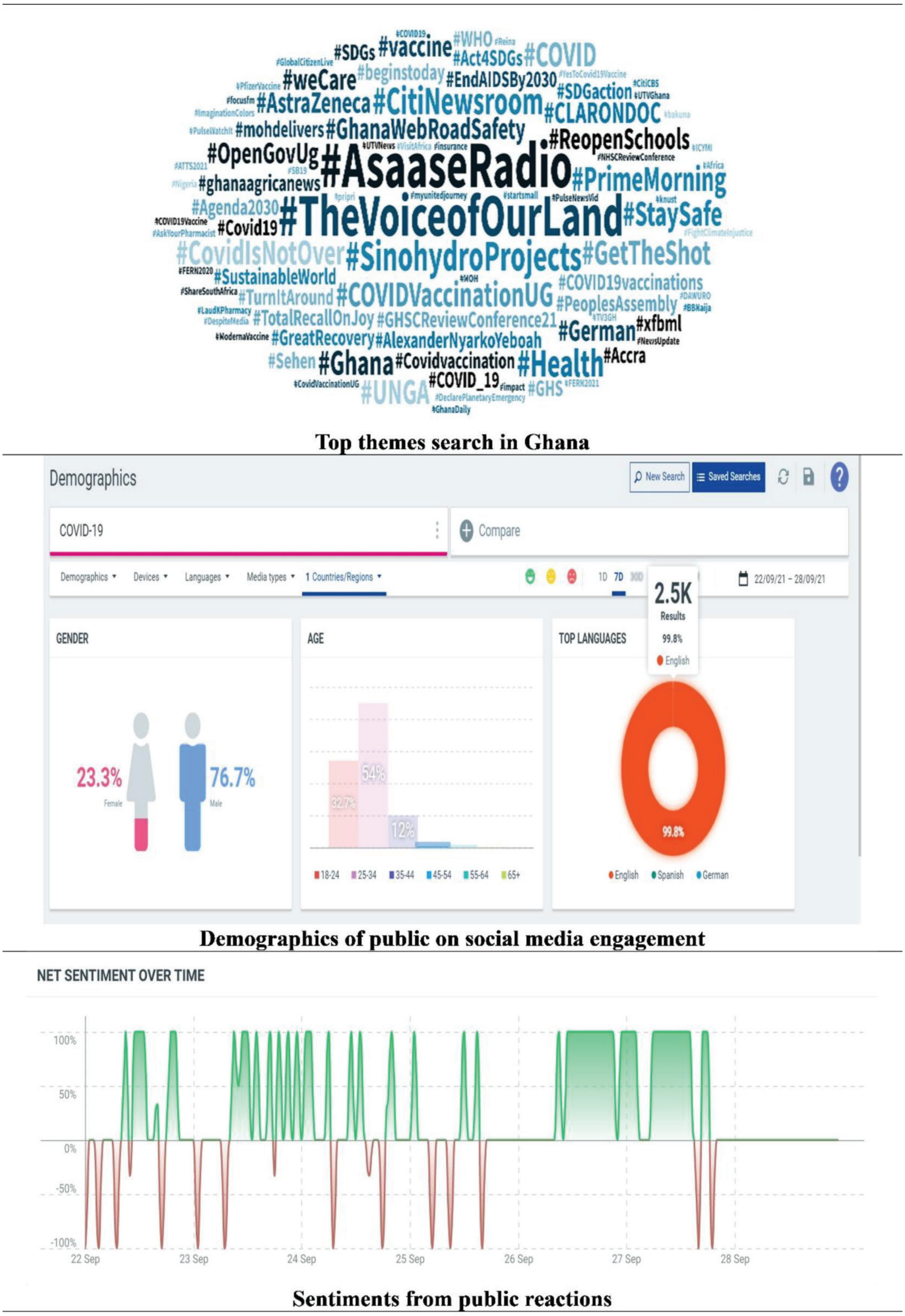

Figure 4. Analytics from media scanning during COVID-19 Pandemic.

providing them with immediate information on precautionary measures to be taken. It also provides details on the nearest health facility where individuals can report the case (Fig. 5).

GEPP is a tool that helps the public report their symptoms easily and connects them with health authorities. It also ensures prompt medical attention by linking users to nearby healthcare facilities or clinicians. Furthermore, it fosters community awareness and caution by alerting users about areas with disease outbreaks. However, it also faces some challenges, such as only working with certain Android versions, leaving out some potential users, and only being available on Android, limiting its reach and impact for iOS and other OS users.

Once fully deployed, this system aims to enhance disease surveillance and response by bringing it closer to citizens. By providing real-time alerts and guidance, it can contribute to curbing the spread of infectious diseases in the future.

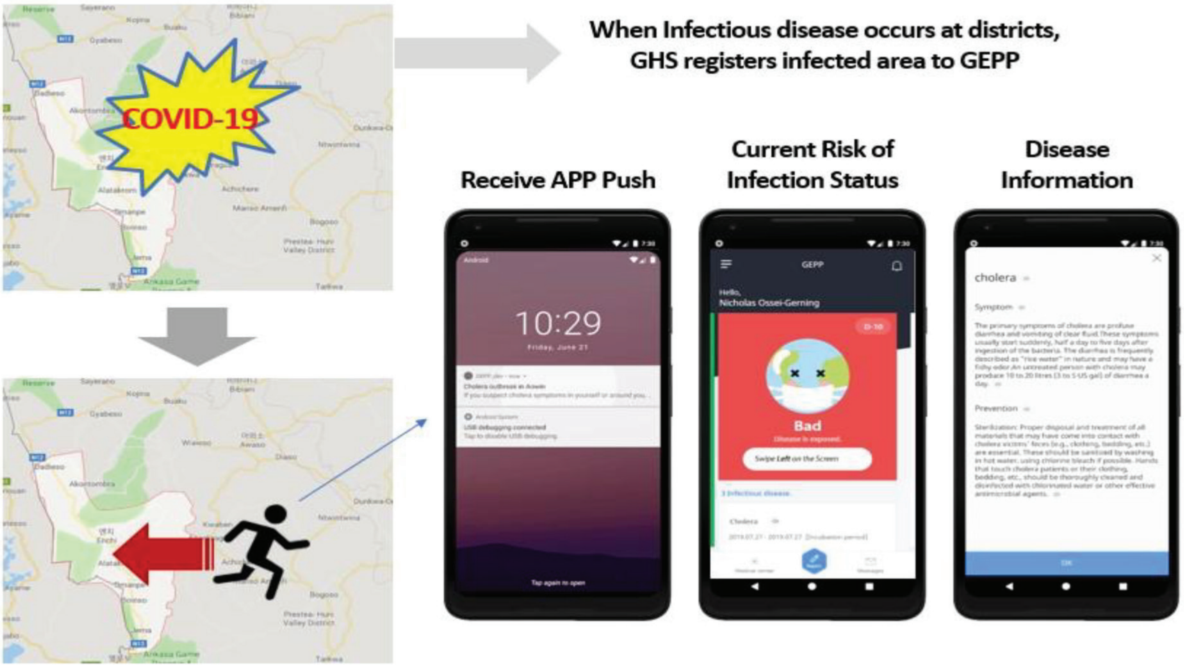

Figure 5. GEPP operational flow.

ArcGIS survey 123. During the initial phase of the pandemic response, the Environmental Systems Research Institute (ESRI) provided a stop-gap application tool called ArcGIS Survey 123. This tool was adopted to collect real-time data on confirmed cases of COVID-19 and their contacts, enabling informed decision-making. The system consists of four modules designed to enhance contact tracing, laboratory data management, geospatial visualization of cases, and sample data (20).

Field officers were responsible for entering data into the system, and updates were reflected in real-time. The ArcGIS Survey 123 application served as a temporary solution until the nationwide implementation of the SORMAS.

ArcGIS Survey 123 is a system that enables data collection and updating in real-time, which can improve the information's timeliness and accuracy and help with contact tracing and follow-up of cases. It also works with the ArcGIS platform, which can offer powerful tools for data analysis, visualization, and mapping, such as dashboards, charts, tables, and filters. Furthermore, it is a flexible and customizable system that can be adjusted to fit different contexts and needs of different diseases and scenarios. However, it also faces some challenges, such as needing data entry and verification by human operators, which can cause errors or inconsistencies in the data quality and completeness, and not integrating fully with other existing digital systems or platforms, such as electronic medical records or health information systems, which can result in duplication or fragmentation of data sources.

District health information system 2. The DHIS 2 (District Health Information System 2) serves as the primary health information management system in Ghana for capturing and managing aggregate data related to the 'Integrated Disease Surveillance and Response (IDSR)' framework. It facilitates data entry at various levels, from sub-district to district, regional, and national levels. DHIS 2 is an open-source software that has been utilized in Ghana for over a decade.

During the COVID-19 response in Ghana, the officers from the Ghana Health Service developed a specific module within the DHIS 2 system to address the needs of the pandemic. This module primarily focused on supporting the nationwide COVID-19 vaccination campaign, capturing crucial biodata of the population and other essential information. The module included a Vaccination registry to record vaccination data and an Adverse Events Following Immunization (AEFI) reporting registry. This system ensured that all vaccination data were received in real-time by decision-makers, enabling timely and informed actions to be taken.

For capturing vaccination data during campaigns, DHIS 2 is a system that allows data entry and management in a standardized and efficient way at various levels of the health system, from sub-district to national levels. It also enhances the timeliness and accuracy of the information and facilitates decision-making and action-taking by supporting real-time data transmission and updating. However, it also faces some challenges, such as requiring internet connectivity that is available and reliable for synchronization, which can be difficult in some remote or low-resource settings or during network disruptions, and needing data entry and verification by human operators, which can cause errors or inconsistencies in the data quality and completeness.

The information entered into the system was used to generate daily reports on vaccination coverage updates across the country.

Lightwave health information management system. The LHIMS is an application designed for managing health records, laboratory data, and patient information. It serves as a comprehensive system used at selected health facilities in Ghana, serving various purposes including disease surveillance. The LHIMS provides real-time data on patients at health facilities, including their diagnoses. The system can send notifications to disease surveillance officers when specific diagnoses made by clinicians meet the case definition of priority diseases, including COVID-19. This functionality allows for timely identification and response to potential cases of infectious diseases.

By providing real-time data on patients at health facilities, including their diagnoses, LHIMS is a system that can improve the information's accuracy and completeness and help with clinical decision-making and care. It can also enable timely identification and response to potential cases of infectious diseases by sending notifications to disease surveillance officers when specific diagnoses made by clinicians match the case definition of priority diseases, such as COVID-19. Furthermore, it can provide valuable insights into the health situation and trends by supporting data analysis and visualization, such as dashboards, charts, tables, and indicators. However, it also faces some challenges, such as requiring internet connectivity that is available and reliable, which can be difficult in some remote or low-resource settings or during network disruptions, having a limited rollout that did not cover all major health facilities in the country, not capturing all aspects of the health situation or response, such as social, economic, or behavioural factors, which may require additional data sources or methods to measure and monitor, and facing technical or operational challenges, such as data security risks, maintenance costs, or user feedback and support issues, which can affect its functionality and reliability.

During the COVID-19 pandemic in Ghana, the LHIMS played a significant role in providing data for surveillance purposes. The system aided in capturing and monitoring COVID-19 cases, enabling public health actions to be taken based on the collected information. The real-time data provided by LHIMS facilitated timely decision-making and response strategies to mitigate the spread of the virus.

Limitations/Challenges. Despite the notable advantages gained from the implementation of various digital surveillance tools during the COVID-19 response in Ghana, there were significant challenges that must be addressed for effective future outbreak response.

One major hurdle was the inadequate internet connectivity in rural areas of the country. The functionality of the SORMAS heavily relied on a stable internet connection to synchronize data with the national server. Unfortunately, due to poor connectivity, data synchronization was often incomplete, resulting in delays in actions such as updating laboratory results.

Moreover, the insufficient availability of ICT logistics, including tablets, phones, and computers, hindered the efficiency of SORMAS and other systems deployed for the response. Some districts had limited access to devices with the necessary software, leading to prolonged data entry processes for suspected cases before samples could be sent for testing. Contact tracers also faced challenges in utilizing the systems due to inadequate logistical support, forcing them to rely on paper-based contact tracing methods, which introduced additional inefficiencies.

Another significant challenge was the lack of interoperability among the different systems utilized. Although multiple systems were adopted, each required a distinct set of information to be inputted, placing a considerable burden on EOC officers who had to regularly update and reconcile the data across various platforms.

Despite these challenges, it is important to acknowledge that the implemented systems were able to achieve their intended purposes within the COVID-19 response strategy.

Addressing these challenges will be crucial for future outbreak responses, including improving internet connectivity in rural areas, ensuring sufficient ICT logistics for effective system usage, and promoting interoperability among different systems to streamline data management and decision-making processes.

Conclusions

While it is true that Ghana's fight against the COVID-19 pandemic saw some success due to the adoption of various digital surveillance tools and technology, a critical examination reveals both the strengths and limitations of these approaches.

The implementation of digital surveillance platforms undoubtedly provided valuable benefits, such as the generation of daily COVID-19 situational updates, the identification of hotspots, and real-time monitoring of imported cases at airports. Additionally, these tools allowed for the assessment of public opinions regarding government interventions to control the spread of the virus.

However, it is essential to recognize that the effectiveness of these digital systems relies heavily on reliable internet connectivity, adequate resources, and widespread access to technology. Unfortunately, Ghana still faces significant challenges in terms of poor internet connectivity, limited availability of ICT infrastructure, and unequal digital access, particularly in rural areas. These limitations hindered the full potential and equitable use of digital surveillance tools throughout the country.

Moreover, while the successes achieved during the pandemic are noteworthy, it is important to consider the long-term sustainability and feasibility of relying solely on digital systems. The transition from traditional methods to digital transformation in the health sector requires substantial investments, comprehensive planning, and careful consideration of potential gaps and vulnerabilities in the system. The replacement of traditional systems with digital platforms should not neglect the importance of human resources, local expertise, and community engagement in healthcare delivery.

Therefore, while acknowledging the benefits derived from the adoption of digital surveillance tools, it is crucial for the government and stakeholders to approach the digital transformation of the health sector with a critical lens. Investments should not only focus on technological advancements but also address the underlying infrastructure, connectivity, and accessibility gaps to ensure equitable and sustainable implementation. The success of Ghana's fight against the COVID-19 pandemic should serve as a catalyst for thoughtful and inclusive digital transformation, rather than assuming a complete replacement of traditional systems in the future.

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Contributions

IO, played a key role in conceiving the idea for the study; IO, GKA, EA, NAA, MA, contributed to drafting the manuscript; IO, IA, RAM, were involved in the final write-up of the paper; IO, EK, RGA, CA, KA, ANA, FAB, critical evaluation of intellectual content of the manuscript. All the authors approved the final version to be published.

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Ethical approval and consent to participate

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Availability of data and material

Data and materials are available by the authors.

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The findings of this study were also presented at the One Health Conference, which took place from 27th to 28th September 2021 at the University of Ghana, Legon.

Conflict of interest

The authors declare no potential conflict of interest.

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References

1. Spinelli A and Pellino G: COVID-19 pandemic: Perspectives on an unfolding crisis. Br J Surgery 107: 785-787, 2020.
2. Maharana A, Amutorine M, Sengeh MD and Nsoesie EO: COVID-19 and beyond: Use of digital technology for pandemic response in Africa. Sci Afr 14: e01041, 2021.
3. Kenu E, Odikro MA, Malm KL, Asiedu-Bekoe F, Noora CL, Frimpong JA, Calys-Tagoe B and Koram KA: Epidemiology of COVID-19 outbreak in Ghana, 2020. Ghana Med J 54: 5-15, 2020.
4. Sarkodie B, Asiedu-Bekoe F, Laryea DO, Ampofo WK, Phillips RO, Samba A, Da Costa A, Nsiah-Asare A, Asamoah-Baah A, Odame E, *et al*: Overview of preparedness and response to COVID-19 in Ghana. Ghana Med J 55: 38-47, 2021.
5. Kim Y: Tracking bodies in question: Telecom companies, mobile data, and surveillance platforms in South Korea's epidemic governance. Inf Commun Soc 25: 1717-1734, 2022.
6. Dan-Nwafor C, Ochu CL, Elimian K, Oladejo J, Ilori E, Umeokonkwo C, Steinhardt L, Igumbor E, Wagai J, Okwor T, *et al*: Nigeria's public health response to the COVID-19 pandemic: January to May 2020. J Glob Health 10: 020399, 2020.
7. Budd J, Miller BS, Manning EM, Lampos V, Zhuang M, Edelstein M, Rees G, Emery VC, Stevens MM, Keegan N, *et al*: Digital technologies in the public-health response to COVID-19. Nat Med 26: 1183-1192, 2020.
8. Kostkova P, Saigí-Rubió F, Eguia H, Borbolla D, Verschuuren M, Hamilton C, Azzopardi-Muscat N and Novillo-Ortiz D: Data and digital solutions to support surveillance strategies in the context of the COVID-19 pandemic. Front Digit Health 3: 707902, 2021.
9. Rahman MS, Peeri NC, Shrestha N, Zaki R, Haque U and Hamid SHA: Defending against the Novel Coronavirus (COVID-19) outbreak: How can the Internet of Things (IoT) help to save the world? Health Policy Technol 9: 136-138, 2020.
10. Ferretti L, Wymant C, Kendall M, Zhao L, Nurtay A, Abeler-Dörner L, Parker M, Bonsall D and Fraser C: Quantifying SARS-CoV-2 transmission suggests epidemic control with digital contact tracing. Science 368: eabb6936, 2020.
11. Whitelaw S, Mamas MA, Topol E and Van Spall HGC: Applications of digital technology in COVID-19 pandemic planning and response. Lancet Digit Health 2: e435-e440, 2020.
12. Silenou BC, Tom-Aba D, Adeoye O, Arinze CC, Oyiri F, Suleman AK, Yinka-Ogunleye A, Dörrbecker J, Ihekweazu C and Krause G: Use of surveillance outbreak response management and analysis system for human monkeypox outbreak, Nigeria, 2017-2019. Emerg Infect Dis 26: 345-349, 2020.
13. Tom-Aba D, Silenou BC, Doerrbecker J, Fourie C, Leitner C, Wahnschaffe M, Strysewske M, Arinze CC and Krause G: The surveillance outbreak response management and analysis system (SORMAS): Digital health global goods maturity assessment. JMIR Public Health Surveill 6: e15860, 2020.
14. Louw C, Paffenholz R, Verset C and Krause G: Global good open source software development in response to the COVID-19 Pandemic-perspectives from SORMAS implementation in Europe. Stud Health Technol Inform 294: 669-673, 2022.
15. Moreno A, Fuentes-Lara C and Navarro C: COVID-19 communication management in Spain: Exploring the effect of information-seeking behavior and message reception in public's evaluation. Investigación en Información y Comunicación: 29, 2020. doi:10.3145/epi.2020.jul.02.
16. Bos VLLC, Jansen T, Klazinga NS and Kringos DS: Development and actionability of the dutch COVID-19 dashboard: Descriptive assessment and expert appraisal study. JMIR Public Health Surveill 7: e31161, 2021.
17. Akyereko E, Nuamah HG, Acheampong GK, *et al*: Completeness of health declaration reports during COVID-19 pandemic in Ghana: Evidence from Travellers' Surveillance data, 2020. Int J Trop Dis Health, 35-43, Published online April 30, 2022.
18. Kawchuk G, Hartvigsen J, Harsted S, Nim CG and Nyirö L: Misinformation about spinal manipulation and boosting immunity: An analysis of Twitter activity during the COVID-19 crisis. Chiropr Man Therap 28: 34, 2020.
19. Lohiniva AL, Nurzhynska A, Hudi AH, Anim B and Aboagye DC: Infodemic management using digital information and knowledge cocreation to address COVID-19 Vaccine Hesitancy: Case Study From Ghana. JMIR Infodemiology 2: e37134, 2022.
20. Owusu AB, Afagbedzi SK, Bandoh DA, Frimpong JA, Kissiedu IN, Aikins BE, Hinneh R and Kenu E: Integration of multiple geospatial applications and intelligence for responding to COVID-19 in Ghana. Ghana Med J 55: 10-20, 2021.