Implementing epidemic intelligence in the WHO African region for early detection and response to acute public health events

George Sie Williams1*, Benido Impouma1,2,*, Franck Mboussou1, Theresa Min-Hyang Lee1, Opeayo Ogundiran1, Charles Okot1, Tatiana Metcalf1, Mary Stephen1, Senait Tekeste Fekadu1, Caitlin M. Wolfe1,3, Bridget Farham1, Cristina Hofer4, Bertil Wicht5,6, Claudia Codeço Tores7, Antoine Flahault2 and Olivia Keiser2

1World Health Organization Regional Office for Africa, Brazzaville, Congo; 2Institute of Global Health, University of Geneva, Geneva, Switzerland; 3College of Public Health, University of South Florida, Tampa, Florida, USA; 4Infectious Diseases Department, Universidad Federal do Rio de Janeiro Medical School, Rio de Janeiro, Brazil; 5University of Lausanne, Lausanne, Switzerland; 6Graph Network, Geneva, Switzerland and 7Fundação Oswaldo Cruz, Rio de Janeiro, Brazil

Abstract

Epidemic intelligence activities are undertaken by the WHO Regional Office for Africa to support member states in early detection and response to outbreaks to prevent the international spread of diseases. We reviewed epidemic intelligence activities conducted by the organisation from 2017 to 2020, processes used, key results and how lessons learned can be used to strengthen preparedness, early detection and rapid response to outbreaks that may constitute a public health event of international concern. A total of 415 outbreaks were detected and notified to WHO, using both indicator-based and event-based surveillance. Media monitoring contributed to the initial detection of a quarter of all events reported. The most frequent outbreaks detected were vaccine-preventable diseases, followed by food-and-water-borne diseases, vector-borne diseases and viral haemorrhagic fevers. Rapid risk assessments generated evidence and provided the basis for WHO to trigger operational processes to provide rapid support to member states to respond to outbreaks with a potential for international spread. This is crucial in assisting member states in their obligations under the International Health Regulations (IHR) (2005). Member states in the region require scaled-up support, particularly in preventing recurrent outbreaks of infectious diseases and enhancing their event-based surveillance capacities with automated tools and processes.

Introduction

The increasing burden of public health crises resulting from epidemics and humanitarian emergencies continue to pose challenges, particularly in countries with weak health systems [1, 2]. Of particular concern are infectious disease outbreaks, which continue to threaten regional and international public health security [3, 4]. These outbreaks are driven by mass population movements, extensive transport networks, climate change and other ecological and environmental factors that facilitate the emergence and global spread of infectious pathogens [5, 6]. In the African region, where more than 100 infectious disease outbreaks are detected and responded to annually [7], the risk is even higher due to the limited capacities of most countries to detect and respond to these events [8]. Limited efficacy and availability of proven public health preventive interventions as a result of the challenges faced by disease control programmes particularly in sub-Saharan Africa add to this risk [9]. Outbreaks of severe acute respiratory syndrome (SARS), Ebola virus disease (EVD) in West Africa and the Democratic Republic of Congo and the ongoing coronavirus disease 2019 (COVID-19) pandemic have shown that these events not only cost lives but also disrupt trade and economic activities, costing millions or billions of dollars [10, 11]. This underscores the urgent need for tools and processes that are used to facilitate early detection and response to these public health events to mitigate their impact. In addition to indicator-based surveillance, the International Health Regulations (IHR) 2005, emphasise the need for event-based surveillance to be used as part of holistic epidemic intelligence activities [12, 13]. Epidemic intelligence refers to the collection, processing and analysis of information on potential health-related hazards with the goal of early detection of outbreaks and health-related emergencies [14]. The two main components of epidemic intelligence are indicator-based surveillance, which relies on information from structured or
official sources such as health facility reports or other pre-
identified reporting sites, and event-based surveillance, which
includes information obtained from unstructured sources such as
the media [15, 16]. The latter is responsible for most initial
reports on epidemics [17].

In furtherance of compliance with IHR 2005, several guidance
documents, frameworks and tools have informed the implemen-
tation and scale-up of epidemic intelligence activities in the
African region. These include the WHO Emergency Response
Framework (ERF) [18], Integrated Disease Surveillance and
Response (IDSR) strategy [19], the Global Health Security
Agenda (GHSA) [20] and the Early Warning and Response
Network (EWARN) [21]. Additionally, the internet or social
media has rapidly enhanced epidemic intelligence monitoring of
public health events, providing an exceptional medium for early
detection of outbreaks [22]. Three internet-based platforms that
have been used for epidemic intelligence in the African region
include Early Alerting and Reporting (EAR), the Hazard
Detection and Risk Assessment System (HDRAS) and more
recently the Epidemic Intelligence from Open Sources (EIOS).
The EAR detects and monitors information about chemical, bio-
logical, radiological and nuclear threats (CBRN) as well as pan-
demic influenza [23], and the HDRAS is a platform for
detection and monitoring of acute public health events [24].
EAR has been found to be a feasible model for detecting inten-
tional release of biological agents while HYDRAS has been
deployed to detect outbreaks in mass gathering events [25], [26].
The EIOS encapsulates the experiences of EAR and HDRAS
and serves as a medium to ‘identify, verify, assess, analyze, inter-
pret and communicate relevant information on public health
events for appropriate, timely and effective action’ [27].

The aim of this study is to review the epidemic intelligence
processes adopted by WHO Regional Office for Africa (AFRO)
to support the 47 Member States in the region, its ability to detect,
and report and provide evidence-based assessments for early outbreak
response, as well as lessons learned. We specifically analysed the
ability of the epidemic intelligence activities to detect true out-
breaks, the frequency of outbreak detection and the results of evi-
dence generated from outbreak risk assessments. We emphasise
the need for timely and reliable event detection activities and
describe how lessons learned can inform and guide future use
and scale-up of support to member states in the African region
to strengthen preparedness for, early detection of and rapid
response to outbreaks that may constitute a public health event
of international concern (PHEIC).

**Methods**

We performed a retrospective analysis of epidemic intelligence
activities undertaken at AFRO over a four-year period – 2017
–2020 – focusing on the processes, key outputs and contribution
to the early detection and response to infectious disease outbreaks
across the WHO African region. The WHO African region is
composed of 47 member states, with all but Algeria located in
sub-Saharan Africa [28].

**Epidemic intelligence at AFRO**

Epidemic intelligence activities were implemented in the context
of the IDSR strategy widely adopted in the African region for
early detection of outbreaks [29], consisting of indicator-based
surveillance (IBS), event-based surveillance (EBS) and rapid risk
assessments (RRA). AFRO relied on formal notification of out-
breaks by member states using indicator-based surveillance
while the organisation implemented event-based surveillance
through monitoring of the media from internet-based sources
and rumours (Fig. 1). A standard operating procedure (SOP) on
detection, verification and risk assessment of acute public health
events in the African region was adopted to guide a dedicated
team of epidemiologists in the daily implementation of epidemic
intelligence activities [30].

The IDSR strategy identifies a list of priority diseases with
defined thresholds for determining alert and epidemic levels to
trigger public health response. The implementation of indicator-
based surveillance relied on analysis and interpretation of routine
surveillance data obtained from formal reporting sites (mostly
health facilities) in the respective member states. These data
were shared weekly with AFRO for collation, analysis and moni-
toring of epidemic thresholds of priority diseases across the
region. The outbreaks detected through indicator-based surveil-
ance were officially notified to WHO by member states using
the IHR (2005) Annex 2 decision instrument [31].

Event-based surveillance was performed mainly through
media monitoring using internet-based epidemic intelligence
platforms. The two platforms used during the studied period
were HDRAS and EIOS, with the latter succeeding the former
since June 2018. These platforms pooled epidemic intelligence
information from several expert systems, including Medisys
[32], Global Public Health Intelligence Network (GPHIN) [33],
HealthMap [34] and ProMED [35], among others. They used
automated methods for scraping, filtering and processing news
from media institutions and other relevant online sources,
which were categorised based on key terms such as outbreaks, epi-
demics, disease name, cluster of symptoms or deaths, disaster, etc.
On the platforms, customised boards with sources from 42 lan-
guages filtered articles only of concern to member states in the
African region.

A designated member of the epidemic intelligence team
triaged media articles populating these platforms daily to detect
any signal concerning an acute public health event. A signal
was considered as any information or rumour relating to an
event not yet officially reported to WHO that had caused or
posed a potential risk to human health. The triage process
involved filtering, screening and selecting signals for monitoring
or further verification. During filtering, the designated epidemi-
ologist identified and screened out any duplicate information ana-
ysed that was not automatically de-duplicated by the epidemic
intelligence platforms, and discarded any information not rele-
vant for the purpose of early warning. The potential signals
were further screened by gathering additional information from
relevant sources to ensure that they differed from known events
in terms of disease manifestation, location, number of cases, sus-
pected causal agent and the circumstances under which they
occurred. The final step of triage involved selection of signals
from a screened list of potential signals presented by the desig-
nated epidemiologist. This was determined through discussion
with a team of epidemiologists who used baseline epidemiological
data, reliability of the source, indications of severity, risk of inter-
national spread or the potential to cause large-scale outbreak as
the basis for selection. The selected signals were then shared
with the respective member states via WHO Country Offices
for verification or continued to be monitored for any change in
the situation. A confirmed signal was a signal found to be true
after investigation or verification by the member state and

WHO, while a signal was considered discarded if not verified during the investigation. Confirmed signals that met the requirements of the IHR 2005 Annex 2A decision-making instrument for notification to WHO were deemed as new public health events. Other signals concerning the spread of an already notified outbreak to new geographic areas were monitored, used to gauge the need for a rapid risk assessment and inform public health response actions.

Risk assessment of acute public health events

The WHO guide on rapid assessment of acute public health events [36] was used by AFRO to conduct rapid risk assessments (RRA). These were conducted for 'large-scale events potentially exceeding the response capacity of the affected country, for events with international implications, and those requiring a WHO response' [18]. They assessed the likelihood and consequences associated with three main risk determinants: the potential risk to human health, its potential to spread, and the risk of insufficient control capacities. RRA were systematically undertaken internally by WHO staff to reflect its independent assessment of an event and evidence for decision making. The overall public health risk was categorised as either 'very high', 'high', 'moderate' or 'low' at the global, regional and national levels based on the findings from the RRA. An outbreak was assessed as low risk if it required routine response through the disease control programme while a moderate risk was assigned if the outbreak required some roles and responsibilities in addition to routine response. A high-risk outbreak was an outbreak needing a range of additional control measures including the need to establish command and control structures. A very high risk was the highest level of risk assigned and denoted that the implementation of control measures with serious consequences was highly likely.

Data sources and collection

Data on signals triaged, events detected and RRA performed during the studied period were recorded in the public health event (PHE) database maintained at AFRO as well as the WHO Events Management System (EMS) [37]. The PHE database and the EMS were the primary sources of data for the study.

Data measurement and analysis

We selected only infectious disease outbreaks reported during the studied period for our analysis and categorised them based on their modes of transmission, a similar type of pathogen or pathogenesis, or requiring a similar type of public health intervention (e.g. vaccination). We performed a descriptive analysis of the infectious disease outbreaks detected through the various modes of epidemic intelligence activities. We analysed the frequency of
Table 1. Infectious disease outbreaks and conditions detected by epidemic intelligence activities (event-based and indicator-based surveillance) and reported to WHO in the African region, 2017–2020

| Year of event/disease category | Year/disease or condition | Event-based surveillance n (%) | Indicator-based surveillance n (%) | Total n (%) |
|-------------------------------|---------------------------|--------------------------------|-----------------------------------|-------------|
| **Year of event (n = 415)**   |                           |                                |                                   |             |
| 2017                          | 31 (26.1)                 | 88 (73.9)                      | 119 (28.7)                        |
| 2018                          | 29 (27.9)                 | 75 (72.1)                      | 104 (25.1)                        |
| 2019                          | 22 (23.2)                 | 73 (76.8)                      | 95 (22.9)                         |
| 2020                          | 22 (22.7)                 | 75 (77.3)                      | 97 (23.4)                         |
| **Events of unknown aetiology (n = 4)** | Event of unknown aetiology | 2 (66.7)                       | 1 (33.3)                          | 3 (75.0)    |
|                               | Eruptive fever            | 0 (0.0)                        | 1 (100.0)                         | 1 (25.0)    |
| **Food-and-water-borne diseases (n = 88)** | Aflatoxicosis            | 0 (0.0)                        | 2 (100.0)                         | 2 (2.3)     |
|                               | Botulism                  | 0 (0.0)                        | 1 (100.0)                         | 1 (1.1)     |
|                               | Cholera                   | 25 (40.3)                      | 37 (59.7)                         | 62 (70.5)   |
|                               | Foodborne disease         | 3 (75.0)                       | 1 (25.0)                          | 4 (4.5)     |
|                               | Hepatitis A               | 0 (0.0)                        | 1 (100.0)                         | 1 (1.1)     |
|                               | Hepatitis E               | 1 (14.3)                       | 6 (85.7)                          | 7 (8.0)     |
|                               | Listeriosis               | 0 (0.0)                        | 2 (100.0)                         | 2 (2.3)     |
|                               | Shigellosis               | 0 (0.0)                        | 2 (100.0)                         | 2 (2.3)     |
|                               | Typhoid fever             | 1 (20.0)                       | 4 (80.0)                          | 5 (5.7)     |
|                               | Undiagnosed diarrhoeal disease | 1 (50.0)                   | 1 (50.0)                          | 2 (2.3)     |
| **Parasitic diseases (n = 6)** | Guinea worm disease       | 2 (66.7)                       | 1 (33.3)                          | 3 (50.0)    |
|                               | Scabies                   | 1 (100.0)                      | 0 (0.0)                           | 1 (16.7)    |
|                               | Skin disease              | 1 (100.0)                      | 0 (0.0)                           | 1 (16.7)    |
|                               | Necrotising cellulitis/fasciitis | 0 (0.0)                   | 1 (100.0)                         | 1 (16.7)    |
| **Respiratory diseases (n = 49)** | COVID-19                 | 8 (17.0)                       | 39 (83.0)                         | 47 (95.9)   |
|                               | Influenza A H1N1          | 1 (50.0)                       | 1 (50.0)                          | 2 (4.1)     |
| **Vaccine-preventable diseases (n = 108)** | Measles                   | 10 (27.0)                      | 27 (73.0)                         | 37 (34.3)   |
|                               | Yellow fever              | 1 (4.3)                        | 22 (95.7)                         | 23 (21.3)   |
|                               | Poliomyelitis (cVDPV2)    | 4 (20.0)                       | 16 (80.0)                         | 20 (18.5)   |
|                               | Meningococcal disease     | 3 (15.8)                       | 16 (84.2)                         | 19 (17.6)   |
|                               | Pertussis                 | 0 (0.0)                        | 3 (100.0)                         | 3 (2.8)     |
|                               | Rubella                   | 1 (50.0)                       | 1 (50.0)                          | 2 (1.9)     |
|                               | Diphtheria                | 0 (0.0)                        | 1 (100.0)                         | 1 (0.9)     |
|                               | AEFI                      | 0 (0.0)                        | 1 (100.0)                         | 1 (0.9)     |
|                               | Poliomyelitis (pre-iVDPV1) | 1 (100.0)              | 0 (0.0)                           | 1 (0.9)     |
|                               | Rotavirus                 | 0 (0.0)                        | 1 (100.0)                         | 1 (0.9)     |
| **Vector-borne diseases (n = 77)** | Dengue fever              | 8 (27.6)                       | 21 (72.4)                         | 29 (37.7)   |
|                               | Rift Valley fever         | 2 (12.5)                       | 14 (87.5)                         | 16 (20.8)   |
|                               | Malaria                   | 7 (53.8)                       | 6 (46.2)                          | 13 (16.9)   |
|                               | Chikungunya               | 2 (28.6)                       | 4 (71.4)                          | 7 (9.1)     |
|                               | Plague                    | 2 (40.0)                       | 3 (60.0)                          | 5 (6.5)     |
|                               | Leishmaniasis             | 1 (33.3)                       | 2 (66.7)                          | 3 (3.9)     |
|                               | Zika virus disease        | 0 (0.0)                        | 2 (100.0)                         | 2 (2.6)     |
|                               | Microcephaly              | 0 (0.0)                        | 1 (100.0)                         | 1 (1.3)     |
|                               | West Nile fever           | 0 (0.0)                        | 1 (100.0)                         | 1 (1.3)     |

(Continued)
these outbreaks and their geographic distribution across the African region.

We also analysed the proportion of outbreaks detected and positive predictive values (PPV) of the media monitoring implemented through the internet-based epidemic intelligence platforms for the top 16 infectious disease outbreaks reported. An outbreak was considered as detected if a signal concerning the outbreak was found via the epidemic intelligence platforms before they were officially reported to WHO. This metric measured the ability of the epidemic intelligence platforms to detect an outbreak and was calculated as the total number of outbreaks detected divided by the total number of outbreaks for a disease. The results were expressed as a percentage. The PPV measured whether a signal selected through the triage process could or could not be confirmed and was calculated as the number of confirmed signals divided by the total signals selected, expressed as a percentage. The frequency and risk level categorisation were analysed for the top 11 frequent infectious disease outbreaks with finalised RRA.

R version 4.0.3 [38] was used for statistical analysis and ESRI 2017 ArcGIS Pro 2.1.0 [39] for mapping of the data.

Results

A total of 415 substantiated infectious disease outbreaks were detected through epidemic intelligence activities and reported to WHO from 2017 to 2019, with 25% \((n = 104)\) initially detected through event-based surveillance and 75% \((n = 311)\) through indicator-based surveillance (Table 1). During the studied period, about 100 infectious disease outbreaks were reported each year, although the number of new outbreaks decreased slightly over time. The most frequent outbreak categories were vaccine-preventable diseases \((n = 108)\), followed by food-and-water-borne \((n = 88)\) and vector-borne diseases \((n = 77)\) (Table 1). The most frequent diseases causing outbreaks were cholera \((n = 62)\), COVID-19 \((n = 47)\), measles \((n = 37)\), dengue fever \((n = 29)\) and Ebolavirus haemorrhagic fever \((CCHF)\) \((n = 26)\). Cholera \((40.3%; n = 25)\) had the most outbreaks initially detected by event-based surveillance, followed by measles \((27.0%; n = 10)\), COVID-19 \((17.0%; n = 8)\), dengue fever \((27.6%; n = 8)\) and CCHF \((19.2%; n = 5)\). The types of surveillance used for the initial detection of each outbreak reported are seen in Table 1.

**Table 1.** (Continued)

| Year of event/disease category          | Year/disease or condition     | Event-based surveillance \(n\) (%) | Indicator-based surveillance \(n\) (%) | Total \(n\) (%) |
|----------------------------------------|-------------------------------|-----------------------------------|-------------------------------------|---------------|
| Viral haemorrhagic fever \((n = 54)\)   | Crimea-Congo haemorrhagic fever | 5 (19.2)                          | 21 (80.8)                           | 26 (48.1)     |
|                                        | Lassa fever                   | 1 (5.3)                           | 18 (94.7)                           | 19 (35.2)     |
|                                        | Ebola virus disease           | 1 (16.7)                          | 5 (83.3)                            | 6 (11.1)      |
|                                        | Marburg                       | 0 (0.0)                           | 2 (100.0)                           | 2 (3.7)       |
|                                        | Acute haemorrhagic fever syndrome | 0 (0.0)                        | 1 (100.0)                           | 1 (1.9)       |
| Zoonotic diseases \((n = 29)\)         | Anthrax                       | 7 (53.8)                          | 6 (46.2)                            | 13 (44.8)     |
|                                        | Monkeypox                     | 1 (7.1)                           | 13 (92.9)                           | 14 (48.3)     |
|                                        | Rabies                        | 1 (50.0)                          | 1 (50.0)                            | 2 (6.9)       |
| Grand total                            |                               | 104 (25.1)                        | 311 (74.9)                          | 415 (100.0)   |

Figure 2 shows a spot map of the geographic distribution of infectious disease outbreaks reported to WHO during the studied period, with at least one outbreak reported from each member state in the African region. Cholera and measles were the most frequent infectious disease outbreaks reported from 2017 to 2019. Additionally, circulating vaccine-derived poliovirus type 2 (cVDPV2) outbreaks emerged among the three most frequent across the region in 2019, while COVID-19 was the most frequent in 2020, with SARS-CoV-2 detected in all the member states of the WHO African region (Fig. 2).

Over 2.8 million unverified media articles were published on the epidemic intelligence platforms from 2017 to 2020 (Fig. 3). Of these, 20 405 media signals were screened with 924 selected and sent to member states for verification. Of the selected media signals, 780 (84.4%) were either confirmed or remained under monitoring while the rest were either discarded or unverifiable. From the confirmed media signals, 104 new public health events were detected (Fig. 3).

Of the 358 outbreaks caused by the 16 most frequent diseases reported to WHO from 2017 to 2020, 24% \((n = 86)\) were initially detected through the epidemic intelligence platforms before official notification to WHO (Table 2). Detection ranged from 4.3% for yellow fever to 53.8% for anthrax and malaria. The most frequent disease outbreak detected was cholera \((n = 25)\) followed by measles \((n = 8)\). Table 2 further showed that of 1018 media signals selected for the top 16 diseases reported, 33% were confirmed with positive predictive values ranging from 8.5% for COVID-19 to 57.6% for measles. EVD \((n = 100)\) had the highest number of signals confirmed (Table 2).

A total of 178 RRA were conducted for infectious disease outbreaks during the studied period with cholera \((24.2%; n = 43)\) being the most frequent, followed by EVD \((13.5%; n = 24)\), yellow fever \((10.1%; n = 18)\), dengue fever \((6.1%; n = 11)\) and Lassa fever \((5.6%; n = 10)\) (Fig. 4). Further, RRA found most outbreaks to have high risk \((47.7%; n = 83)\) at national level, moderate risk \((42.5%; n = 74)\) at regional level and low risk \((92.9%; n = 169)\) at global level (Fig. 4). Only outbreaks of cholera and EVD reached very high risk at both national and regional levels. All outbreaks were assessed as low risk at the global level except for COVID-19, which was considered very high due to the ongoing pandemic.
Discussion

Epidemic intelligence activities have detected and verified a large number of infectious disease outbreaks in the WHO African region, highlighting the frequency of outbreaks of cholera and measles over the whole study period. In 2019 outbreaks of cVDPV2 increased in frequency, while in 2020 the global pandemic of COVID-19 was reflected in the frequency of its detection and wide geographical spread across the region. Our results have shown that epidemic intelligence activities have contributed to the detection and reporting of infectious diseases across the region.

Although IDSR specifies the use of both indicator and event-based surveillance, we found that the member states mainly relied on formal reporting sites for the detection of outbreaks, thus the high number initially detected through indicator-based surveillance. According to Fall et al., implementation of event-based surveillance was inadequate despite the wide adoption and scale-up of IDSR across the African region [40]. The initial detection of a quarter of all outbreaks through event-based surveillance from media sources showed that this mode of epidemic intelligence is a useful complement in the early detection of outbreaks. This point has been reinforced in the third edition of the IDSR technical guidelines, recently adopted by the WHO African region [41].

Although vaccines are known to be one of the most efficient, high-impact public health measures to prevent diseases, immunisation rates across most of the WHO African region have been sub-optimal, mainly challenged by issues related to funding, stock-outs, logistics and accessibility, among others [42]. Our finding of high frequency and recurrence of vaccine-preventable disease outbreaks in the region during the studied period could...
be attributed to these challenges. Food-and-water-borne disease outbreaks have also remained prevalent in the region, with cholera being the most frequently detected and reported. Poor water, sanitation and hygiene (WASH) infrastructures are the most cited key factors driving the recurrence of food-and-water-borne disease outbreaks, however, the role of environmental reservoirs as well as anthropogenic and hydroclimatic drivers have also been highlighted [43].

Additionally, the changing environment, particularly changes in the socio-ecological systems and climate, have undoubtedly influenced the recurrence of outbreaks of some emerging and reemerging diseases, which we categorised as vector-borne and viral haemorrhagic fevers [44]. There are recurrent outbreaks of these diseases, such as dengue fever, Rift Valley fever, CCHF, Lassa fever and EVD. Also, the emergence of several outbreaks of cVDPV2 in 2019 and the spread of SARS-CoV-2 globally in

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Table 2. Percent of events detected and positive predictive values of the most frequent events identified through epidemic intelligence in the WHO African region, 2017–2020

| Event                 | Frequency of event | Detected events | Per cent detected (%) | Media articles | Media signals selected | Signals confirmed/monitored | PPV (%) |
|-----------------------|--------------------|-----------------|-----------------------|----------------|------------------------|-----------------------------|---------|
| Cholera               | 62                 | 25              | 40.3                  | 25 059         | 153                    | 64                          | 41.8    |
| COVID-19              | 47                 | 8               | 17.0                  | 1 256 060      | 164                    | 14                          | 8.5     |
| Measles               | 37                 | 10              | 27.0                  | 27 012         | 59                     | 34                          | 57.6    |
| Dengue fever          | 29                 | 8               | 27.6                  | 5525           | 20                     | 10                          | 50.0    |
| CCHF                  | 26                 | 5               | 19.2                  | 1932           | 22                     | 9                           | 40.9    |
| Yellow fever          | 23                 | 1               | 4.3                   | 6136           | 21                     | 13                          | 61.9    |
| Poliomyelitis         | 20                 | 4               | 20.0                  | 15 161         | 11                     | 1                           | 9.1     |
| Meningococcal disease| 19                 | 3               | 15.8                  | 12 505         | 13                     | 6                           | 46.2    |
| Lassa fever           | 19                 | 1               | 5.3                   | 6418           | 36                     | 7                           | 19.4    |
| Rift Valley fever     | 16                 | 2               | 12.5                  | 1186           | 9                      | 2                           | 22.2    |
| Monkeypox             | 14                 | 1               | 7.1                   | 1239           | 16                     | 6                           | 37.5    |
| Anthrax               | 13                 | 7               | 53.8                  | 1563           | 46                     | 23                          | 50.0    |
| Malaria               | 13                 | 7               | 53.8                  | 36 150         | 82                     | 40                          | 48.8    |
| Hepatitis E           | 7                  | 1               | 14.3                  | 871            | 25                     | 5                           | 20.0    |
| Chikungunya           | 7                  | 2               | 28.6                  | 2413           | 4                      | 2                           | 50.0    |
| Ebola virus disease   | 6                  | 1               | 16.7                  | 92 677         | 337                    | 100                         | 29.7    |
| Total                 | 358                | 86              | 24.0                  | 1 491 907      | 1018                   | 336                         | 33.0    |

*Detected events are events detected via epidemic intelligence platforms before they were officially reported to WHO.

bPer cent of events detected via the epidemic intelligence platforms before being officially reported to WHO.

PPV, positive predictive value, is defined as the proportion of selected media signals that were confirmed or monitored after verification.
2020 in all members states of the WHO African region highlights the effects of novel diseases and conditions on human health and development in the region.

With the increasing threat of emerging and reemerging infectious diseases, the role of epidemic intelligence remains crucial for preparedness and response to these events. Integrated surveillance systems such as IDSR, when implemented holistically, are central to early detection of outbreaks and, most importantly, can help mitigate the devastating social and economic consequences of epidemics. The ability of media monitoring to detect several outbreaks not only confirms the invaluable contribution of internet-based sources to early outbreak detection, but also emphasises how adopting standardised and thorough processes for triaging rumours can reduce noise and improve the PPV of media monitoring.

Moreover, the epidemic intelligence activities undertaken at AFRO may have contributed to the early detection of outbreaks and indirectly influenced the timeliness of WHO response actions to support member states in mounting public health response to outbreaks with potential for international spread. Impouma et al. found that the timeliness of detection and control of outbreaks across the African region improved from 2017 to 2019, attributed to enhanced epidemic intelligence, among other factors [45]. For example, in 2017 WHO received initial information on a cluster of cases presenting with EVD-like symptoms in the Democratic Republic of the Congo three days before the event was confirmed and officially notified by the country. A verification request from WHO to the member state triggered field level investigation and within 24 h of confirmation and official notification, an RRA was finalised, which provided the basis for further operational actions. The rapid response mounted by the member state with support from WHO and partners cannot be discounted among factors that led to an eventual control of the outbreak within two months.

The WHO emergency response framework requires evidence for decision making when supporting member states’ response to epidemics [18]. The RRA provided the evidence base with which to inform the scale of WHO support in order to implement appropriate and timely public health response measures. The high frequency of RRA for some outbreaks such as cholera, EVD, dengue fever and Lassa fever highlighted the potential of these outbreaks to cause significant impact to human health. Most outbreaks were assessed as high risk at national level, indicating that these outbreaks could quickly overwhelm national capacities and spread to new sub-national areas, with high morbidity and mortality. While most outbreaks had moderate risk at the regional level, outbreaks of cholera and EVD were found to have high and very high risk at regional levels indicating their potential to cross national boundaries and affect other member states in the region, resulting in strain on their health systems. COVID-19 was assessed as very high risk at the global level in light of the ongoing pandemic and its impact across the globe.

Implementing epidemic intelligence activities in the African region has not been without challenges. First, event-based surveillance has not been fully scaled-up across the African region, partly due to the additional logistical, human and financial resources that are required for its implementation. While media monitoring undertaken at AFRO have been useful, in-country strengthening of event-based surveillance activities, for example, community-based surveillance and media monitoring, would have further enhanced the timeliness of outbreak detection and response at sub-national levels. Secondly, the internet-based epidemic

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Fig. 4. National, regional, and global levels risk characterization for the top eleven infectious disease outbreaks with frequent rapid risk assessments, WHO African region, 2017–2020 (N = 178).
intelligence platforms generated a high volume of noise, resulting in hundreds or thousands of articles, making triaging laborious. Additionally, while articles from formal media sources have been invaluable, the increasing popularity and use of social media platforms such as Facebook and Twitter in the region could have contributed much more to the pool of epidemic intelligence information if they were included as sources of information on the epidemic intelligence platforms. Thirdly, for some events such as EVD and COVID-19, the heightened awareness, concerns and increased rumours associated with outbreaks meant that many more signals needed to be investigated to rule out new flare-ups or events in order to ensure that the population was protected from any eventual spread of these diseases. The importance of increasing sensitivity to capture all possible signals resulted in lower positive predictive values and increased human and financial resources needed to investigate additional signals. There was a higher importance to acquire sufficient sensitivity at the cost of lower PPV.

There are four main limitations of our analysis. First, our list of outbreaks may not be exhaustive since we considered only those required for notification to WHO as per IHR 2005 Annex 2A decision instrument. Second, the detection metrics is not an ideal measurement for sensitivity. The relatively low detection measured for most of the top 16 infectious disease outbreaks were due to the exclusion of signals appearing on the epidemic intelligence platforms after the outbreaks were officially reported to WHO through other channels. This means that the detection metrics cannot be used as a proxy for sensitivity of the epidemic intelligence platforms, that is, the ability of the platforms to detect outbreaks irrespective of whether first reported to WHO or not. Third, several signals remained unverified as of the time of our analysis and therefore could not be classified as confirmed or discarded. This may have led to underestimation of the positive predictive values reported. Finally, we did not systematically capture data on the number of duplicate articles filtered during the triaging process, hence, we were unable to exclude duplicates from the total number of unique media articles populating the platforms. While the epidemic intelligence platforms automated the de-duplication of some of the articles that were nearly identical in text, there were articles which provided duplicative information which were not filtered out.

**Conclusion**

Despite these challenges and limitations, epidemic intelligence activities have proven useful to the early detection and response to outbreaks in the African region. The adoption of standardised processes and tools for epidemic intelligence, including rapid risk assessments, not only enhanced outbreak detection in the region, but also provided the objective means of monitoring the evolution of outbreaks and generating evidence to guide WHO in the deployment of its resources and technical expertise. The implementation of media monitoring using internet-based platforms in addition to routine indicator-based surveillance, shows that in an increasingly digital world, there is growing reliance on unofficial sources for first reports about outbreaks.

**Recommendations**

We recommend that AFRO continues to invest in strengthening epidemic intelligence as part of preparedness for and response to events of public health concern through building countries’ capacities to implement event-based surveillance including the scale-up of the use of platforms such as EIOS in the African region. Expanding sources on the current epidemic intelligence platforms to include social media would further increase the chances of detecting events early and should be prioritised. There is also a need to strengthen routine disease prevention programmes by addressing factors that limit their effectiveness to prevent recurrent outbreaks.

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**Data availability statement.** The authors confirm that the datasets used for this study are available on request.

**References**

1. Warsame A, Blanchet K and Checchi F (2020) Towards systematic evaluation of epidemic responses during humanitarian crises: a scoping review of existing public health evaluation frameworks. BMJ Global Health 5, 1–10.
2. World Health Organization (2019) A world at risk: annual report on global preparedness for health emergencies. Available at https://apps.who.int/gmpmb/assets/annual_report/GMPB_annualreport_2019.pdf, (Accessed 4 February 2021).
3. Lee VJ et al. (2020) Preparedness for emerging epidemic threats: a lancet infectious diseases commission. Lancet Infectious Diseases 20, 17–19.
4. McCloskey B et al. (2014) Emerging infectious diseases and pandemic potential: status quo and reducing risk of global spread. Lancet Infectious Diseases 14, 1001–1010.
5. Morganstein JC et al. (2017) Pandemics: health care emergencies. In Ursano RJ, Fullerton CS, Weissah L and Raphael B (eds), *Textbook of Disaster Psychiatry*. Cambridge: Cambridge University Press, pp. 270–284.
6. McMichael A (2004) Environmental and social influences on emerging infectious diseases: past, present and future. *Philosophical Transactions Royal Society B* Biological Sciences 359, 1049–1058.
7. WHO Health Emergencies Programme | WHO | Regional Office for Africa. (2017) Available at https://www.afro.who.int/about-us/programmes-clusters/who-health-emergencies-programme (Accessed 4 February 2021).
8. Talisuna A et al. (2019) Joint external evaluation of the International Health Regulations (2005) capacities: current status and lessons learnt in the WHO African region. BMJ Global Health 4, 1–8.
9. Songane M (2018) Challenges for nationwide vaccine delivery in African countries. *International Journal of Health Economics Management* 18, 197–219.
10. Joo H et al. (2019) Economic impact of the 2015 MERS outbreak on the Republic of Korea’s tourism-related industries. Health Security 17, 100–108.
11. Elmahdawy M et al. (2017) Ebola virus epidemic in West Africa: global health economic challenges, lessons learned, and policy recommendations. *Value in Health Regional Issues* 13, 67–70.
12. Merianos A and Peiris M (2005) International health regulations (2005). *Lancet (London, England)* 366, 1249–1251.
13. Fischer JE, Kornblit S and Katz R (2011) The *International Health Regulations* (2005): Surveillance and Response in an Era of Globalization. Washington DC, US: Stimson Center. pp. 1–42. Available at https://www.ijstor.org/stable/pdf/resrep10843.pdf?pref=ovid&sid=excel%7C3A09086e65c0822746bd11aabdbd1c5f0319, (Accessed 4 February 2021).
14. Paquet C et al. (2018) Eurosurveillance_ epidemic intelligence_ a new framework for strengthening disease surveillance in Europe. *Eurosurveillance* 11, 665.
15. World Health Organization. (2015) Epidemic intelligence – systematic event detection. Available at http://www.who.int/csr/alertresponse/epidemicintelligence/en/ (Accessed 4 February 2021).
16. World Health Organization (2014) Early detection, assessment and response to acute public health events: Implementation of Early Warning and Response with a focus on Event-Based Surveillance Interim Version. Available at www.who.int/about/licensing/copyright_form/en/index.html (Accessed 4 February 2021).
17. Heymann DL and Rodier GR (2001) Hot spots in a wired world: WHO surveillance of emerging and re-emerging infectious diseases. *Lancet Infectious Diseases* 1, 345–353.

18. World Health Organization. ERF: Emergency Response Framework – Second Edition. Available at [https://reliefweb.int/report/world/who-emergency-response-framework-second-edition](https://reliefweb.int/report/world/who-emergency-response-framework-second-edition) (Accessed 4 February 2021).

19. World Health Organization (2019) Technical Guidelines for Integrated Disease Surveillance and Response in the African Region: third edition. Available at [https://www.afro.who.int/publications/technical-guidelines-integrated-disease-surveillance-and-response-african-region-third](https://www.afro.who.int/publications/technical-guidelines-integrated-disease-surveillance-and-response-african-region-third) (Accessed 4 February 2021).

20. Wolicki SB et al. (2019) Public health surveillance: at the core of the global health security agenda. *HHS Public Access* 14, 185–188.

21. Cordes KM et al. (2017) Real-time surveillance in emergencies using the early warning alert and response network. *Emerging Infectious Diseases* 23, S131–S137.

22. Yan SJ, Chughtai AA and Macintyre CR (2020) Utility and potential of rapid epidemic intelligence from internet-based sources. *International Journal of Infectious Diseases* 63, 77–87.

23. Barboza P et al. (2013) Evaluation of epidemic intelligence systems integrated in the early alerting and reporting project for the detection of A/H5N1 influenza events. *PLoS One* 8, 1–9.

24. Bernard R et al. (2018) Intelligence and global health: assessing the role of open source and social media intelligence analysis in infectious disease outbreaks. *Journal of Public Health* 26, 509–514.

25. Riccardo F et al. (2014) Interfacing a biosurveillance portal and an international network of institutional analysts to detect biological threats. *Biosecurity and Bioterrorism: Biodefense Strategy, Practice, and Science* 11, 325–336.

26. World Health Organization. Enderlein U and Regmi J (2018) Strengthening public health: making the case for mass gatherings. Public Health Panorama 4, 67–71. [https://www.who.int/publications/i/item/strengthening-public-health-making-the-case-for-mass-gatherings](https://www.who.int/publications/i/item/strengthening-public-health-making-the-case-for-mass-gatherings).

27. World Health Organization (2020) Early detection, verification, assessment and communication [Internet]. Available at [https://www.who.int/covas/coe](https://www.who.int/covas/coe) (Accessed 4 February 2021).

28. World Health Organization (2012) WHO Regional Office for Africa. Making pregnancy safer in Mozambique. Available at [https://www.who.int/about/regions/afro/en/](https://www.who.int/about/regions/afro/en/) (Accessed 4 February 2021).

29. Kasolo F et al. (2013) IDSR as a platform for implementing IHR in African countries. *Biosecurity and Bioterrorism: Biodefense Strategy, Practice, and Science* 11, 163–169.

30. World Health Organization. Standard Operating Procedures for AFRO Strategic Health Operations Centre (AFRO SCHOC). (2014) Available at [https://apps.who.int/iris/bitstream/handle/10665/184672/9789290232803.pdf?sequence=1](https://apps.who.int/iris/bitstream/handle/10665/184672/9789290232803.pdf?sequence=1) (Accessed 4 February 2021).

31. World Health Organization (2010) WHO Guidance for the Use of Annex 2 of the International Health Regulations (2005). 1–60. Available at [https://www.who.int/ihr/publications/annex_2_guidance/en/](https://www.who.int/ihr/publications/annex_2_guidance/en/) (Accessed 4 February 2021).

32. EU Science Hub. Medical Information System – MEDI SYS. (2017) Available at [https://ec.europa.eu/jrc/en/scientific-tool/medical-information-system](https://ec.europa.eu/jrc/en/scientific-tool/medical-information-system) (Accessed 4 February 2021).

33. Public Health Agency of Canada. About GPHIN. (2017) Available at [https://gphin.canada.ca/cepr/aboutgphin-rmispenbref.jsp?language=en_CA](https://gphin.canada.ca/cepr/aboutgphin-rmispenbref.jsp?language=en_CA) (Accessed 4 February 2021).

34. Flu & Ebola Map | Virus & Contagious Disease Surveillance. (2020) Available at [http://www.healthmap.org/en/](http://www.healthmap.org/en/) (Accessed 4 February 2021).

35. ProMed International Society for Infectious Diseases. (2020) Available at [https://promedmail.org/](https://promedmail.org/) (Accessed 4 February 2021).

36. World Health Organization (2017) Rapid risk assessment of acute public health events. Available at [https://www.who.int/ihr/publications/WHO_HSE_GAR_ARO_2012_1/en/](https://www.who.int/ihr/publications/WHO_HSE_GAR_ARO_2012_1/en/) (Accessed 4 February 2021).

37. Training in implementation of Event Management System [Internet]. (2012) Available at: [https://apps.who.int/iris/handle/10665/325015/WHO-AF-WHE-CPI-05.2019-eng.pdf](https://apps.who.int/iris/handle/10665/325015/WHO-AF-WHE-CPI-05.2019-eng.pdf) (Accessed 4 February 2021).

38. The R Foundation (2018) R: The R Project for Statistical Computing. Available at [https://www.r-project.org/](https://www.r-project.org/) (Accessed 4 February 2021).

39. ArcGIS. The mapping and analytics platform. (2020) Available at [https://www.esri.com/en-us/arcgis/about-arcgis/overview](https://www.esri.com/en-us/arcgis/about-arcgis/overview) (Accessed 4 February 2021).

40. Fall IS et al. (2019) Integrated disease surveillance and response (IDSR) strategy: current status, challenges and perspectives for the future in Africa. *BMJ Global Health* 4, 1–11.

41. World Health Organization (2019) Technical guidelines for integrated disease surveillance and response in the WHO African region. Available at [https://apps.who.int/iris/bitstream/handle/10665/325015/WHO-AF-WHE-CPI-05.2019-eng.pdf](https://apps.who.int/iris/bitstream/handle/10665/325015/WHO-AF-WHE-CPI-05.2019-eng.pdf) (Accessed 4 February 2021).

42. Mihigo R et al. (2017) Challenges of immunization in the African Region. *Pan African Medical Journal* 27(Suppl. 3), 12.

43. Gwerni W and Sanganyado E (2019) Current cholera outbreaks in sub-Saharan Africa: moving beyond epidemiology to understand the environmental reservoirs and drivers. *Challenges* 10, 1.

44. Campeau L et al. (2018) Containment measures for emerging and re-emerging vector-borne and other infectious diseases of poverty in urban settings: a scoping review. *Infectious Diseases of Poverty* 7, 1–16. doi: 10.1186/s40249-018-0478-4.

45. Impouma B et al. (2020) Measuring timeliness of outbreak response in the World Health Organization African Region, 2017–2019. *Emerging Infectious Diseases* 26, 2555–2564.