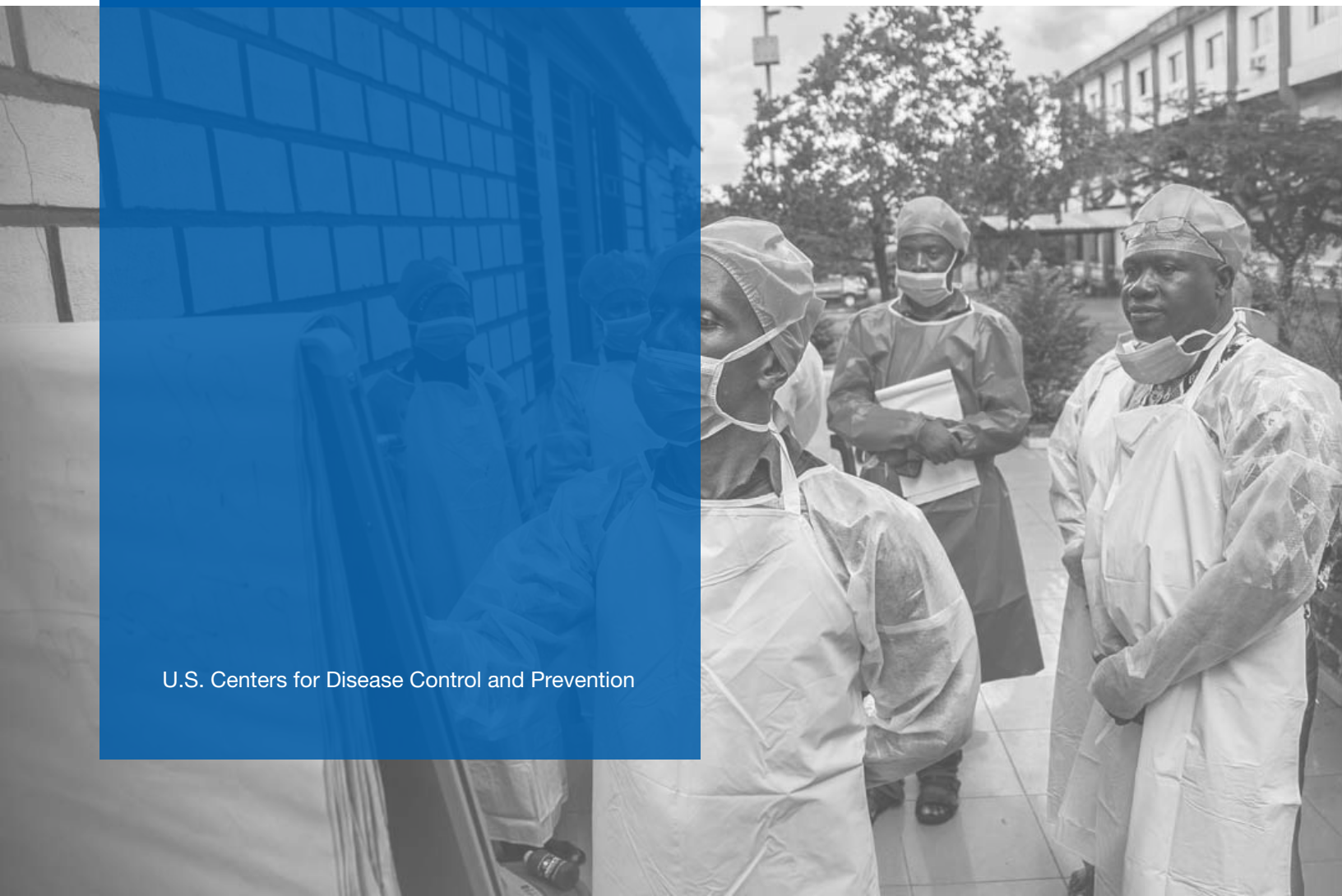
MODULE 1

OVERVIEW OF EVENT-BASED SURVEILLANCE



U.S. Centers for Disease Control and Prevention

INTRODUCTION

The International Health Regulations (IHR; 2005) identifies timely detection of all events with potential public health risk, and immediate reporting and response, as core capacities of surveillance. The IHR expands the usual notification of infectious diseases to include surveillance of public health events of various origins (e.g. nuclear, chemical or unknown). The IHR encourages 196 countries, including all World Health Organization (WHO) Member States, to build the capacity to detect, assess, notify and respond to all acute health events or health risks that may constitute a threat to human health. The WHO Joint External Evaluation (JEE) tool measures country-level progress in achieving these capacities and the WHO has also developed benchmarks to inform the actions countries can take to build IHR capacities, including surveillance capacity, appropriately.

Surveillance, Early Warning and Response, and Epidemic Intelligence

Public health surveillance has two main objectives:

- to measure disease burden, including monitoring morbidity and mortality trends over time to effectively guide control programs and allocation of resources; and
- to enable rapid detection of public health events for effective response and control.

The organized mechanism to achieve rapid detection of public health events is referred to as early warning and response (EWAR). EWAR should collect information from different relevant sources and guide public health response to acute public health events of all origins. The mechanisms of detection and data collection from both indicator-based and event-based surveillance systems, as well as the processes of data management and information-sharing, are collectively called epidemic intelligence. Epidemic intelligence is the systematic collection, analysis and communication of any information to detect, verify, assess, and investigate events and health risks with an early warning objective.

Indicator-Based Surveillance and Event-Based Surveillance

Epidemic intelligence has two components: traditional or indicator-based surveillance (IBS), and event-based surveillance (EBS).

Indicator-Based Surveillance

IBS primarily relies upon information collected in health facilities and focuses on the detection of a list of communicable diseases using standardized case definitions. Thus, IBS is well-suited for monitoring disease trends over time and defining transmission patterns, and is useful for understanding, for instance, the start of regular seasonal outbreaks of endemic disease such as seasonal influenza. Data provided by IBS are essential to EWAR, but IBS may not always be helpful for smaller events because signals are either averaged out in large datasets or lost in the noise of smaller datasets. Additionally, data from IBS systems can often be delayed, incomplete, and may provide information only on a pre-defined list of known public health risks. Emerging or unknown pathogens may, therefore, be missed, along with rapidly escalating outbreaks or non-communicable events such as those attributable to toxicological contaminants.

Event-Based Surveillance

The World Health Organization (WHO) defines EBS as the organized collection, monitoring, assessment and interpretation of mainly unstructured ad hoc information regarding health events or risks. Information from EBS can come from anywhere, including pharmacies, animal health sectors, clinicians, schoolteachers and community members, among others.

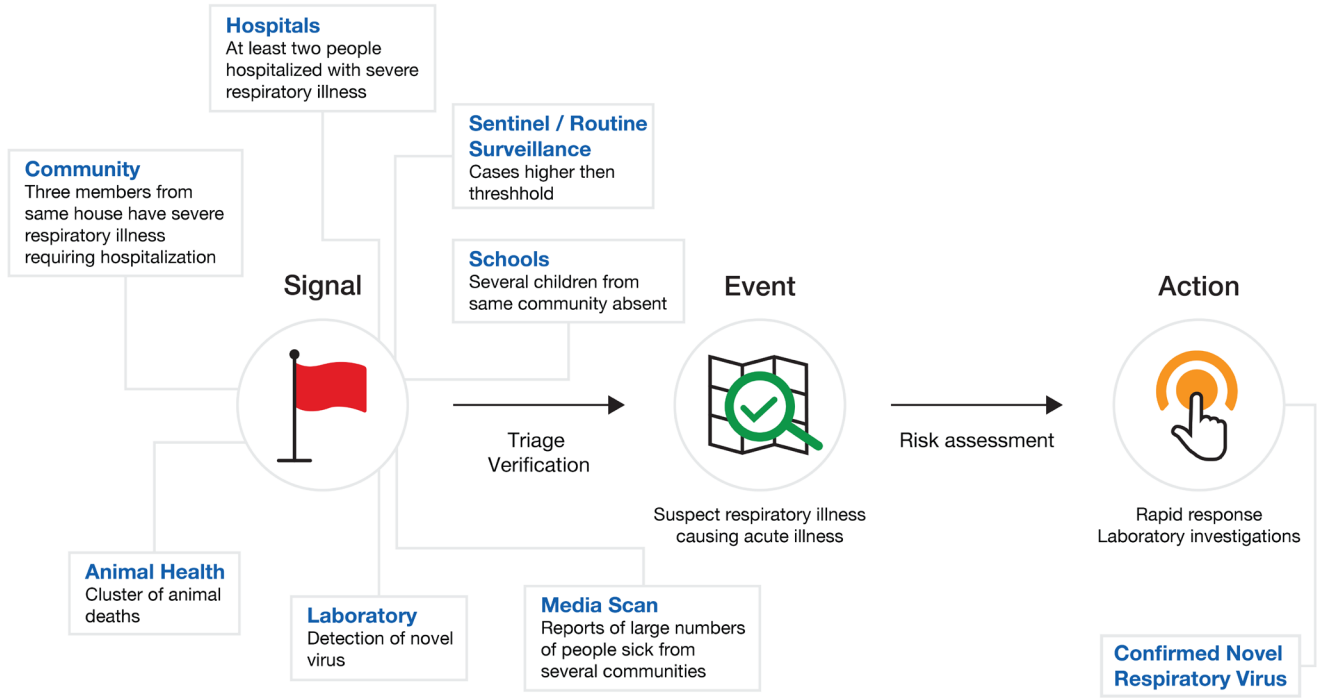
When fully functional, an EBS system:

- Strengthens country preparedness for epidemics and pandemics,
- Complements and enhances existing surveillance and reporting systems,
- Follows an all-hazards approach incorporating One Health, and
- Promotes and facilitates multi-sectoral collaboration and communication, including public and private sectors.

In IHR, an event is defined as "[...]a manifestation of a disease or an occurrence that creates a potential for disease; [...]" and might represent a threat to public health that needs urgent attention, such as an emerging outbreak (see figure below). Events of public health importance vary widely and can be outbreaks of infectious disease; the reappearance of diseases that have been eliminated from a community; outbreaks of human diseases related to food contamination, chemical spills or radiation leaks; or outbreaks of disease in animals that threaten human health.

EBS is a functional component of EWAR that collects information before human cases occur or before an event is detected and reported through traditional reporting systems such as IBS. An optimal EBS system will significantly increase the sensitivity of the public health system and ensure a rapid response to acute public health events of all origins, resulting in mitigation of the public health impact. As such, an EBS system requires, at minimum, an event assessment team/unit and rapid response capacity. It also requires reinforced existing coordination and multi-sectoral collaboration among all stakeholders within and outside of the health sector.

Figure 2. Interaction among different EBS sources



The above figure illustrates an example of how a novel respiratory virus can be detected through a comprehensive EBS system. In this hypothetical scenario, the early warning can come through several sources:

- A CHV or a key informant in the community receiving information about three members of the same household that are severely ill, with two of them rushed to a hospital with severe respiratory illness
- A hospital receiving two severely ill patients from the same household in the emergency unit
- The animal health sector sharing reports of sudden illness and deaths of poultry in several communities and an animal market
- The national public health laboratory detecting an un-typeable virus from hospitalized patients
- Media reporting of increasing public anxiety over several hospitalized cases from one municipality
- A school reporting several children absent with severe respiratory illness

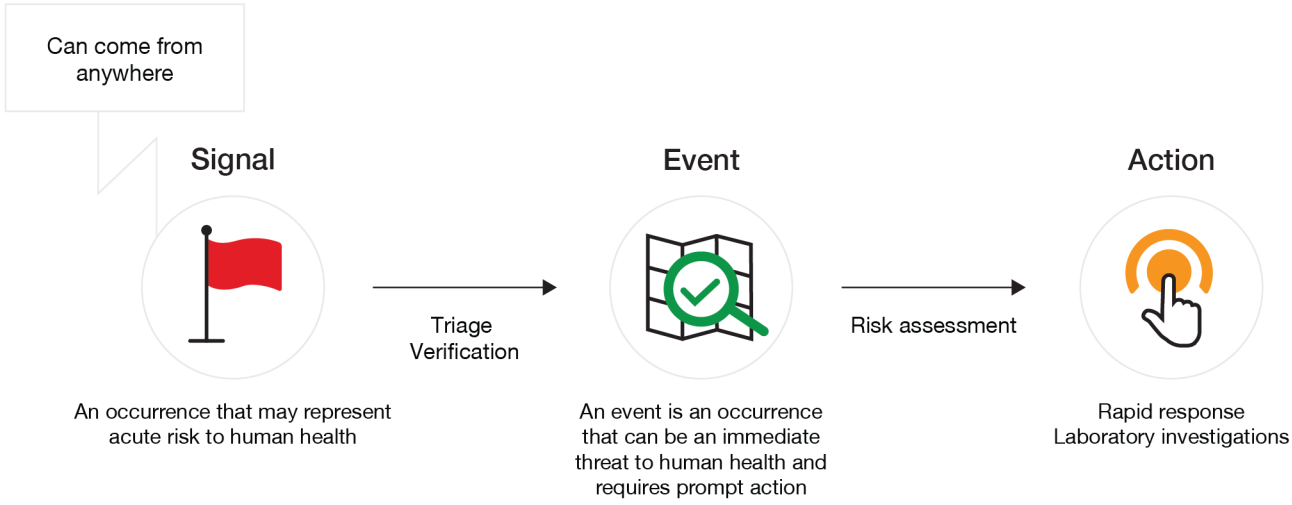
A signal entering the public health system through any source should initiate immediate triage and verification. Since, in this example, the event is verified as a suspected cluster of severe respiratory illness, appropriate response mechanisms can swing into place with coordination across sectors, resulting in rapid intervention that can save lives.

The process of EBS starts with the identification of signals, or observations that indicate an event occurring in a population. Signals can be patterns of disease, such as clusters of similar illness in a community, clusters of disease or death in animals, or even single cases of a high-priority illness such as a child with acute flaccid paralysis or a patient with a viral hemorrhagic fever in a country at risk for the Ebola virus disease. Signals can come from numerous diverse sources, including key informants in community settings, human and animal health care providers, health facilities, media publications, and others.

Each source will define signals differently and may even be more suited for different kinds of disease processes. For instance, community-based surveillance (CBS) is best suited for the early detection of localized events in a community, including those that may subsequently spread. Some of these may only need a local response, as in a case of rabies, while others need to be immediately escalated to a higher level of the public health system for a more aggressive response, such as a case of hemorrhagic fever or a cluster of severe acute respiratory infections. Often, community-level signals need to be defined with simple terms and not using medical jargon.

Because signal definitions are broad and may be detected by informal sources, once detected, signals must be evaluated to determine the likelihood that they truly represent an event. This process includes the steps of triage and verification. Triage is comprised of the sorting of data and information in order to discard duplicates, misinformation, and irrelevant information, to enable the identification of real events. Once triage has been performed, verification is used to confirm the verity and authenticity of the signal, and to collect additional information. Once the signal has been triaged and verified as truly occurring, it may be classified as an event (see figure below). As such, it enters, and is integrated into, the public health surveillance reporting system for appropriate recording and response.

Figure 3. Functions of EBS: From signal to action



All events need to be assessed to determine the level of risk to human health. This step is called risk assessment. Once a risk level is assigned, the appropriate investigation, response/action, and control measures can be elaborated and implemented. Risk assessment should be a dynamic process and may depend in large part on the severity of the underlying process:

- whether or not it is resulting in severe cases or deaths,
- the size of the event, and
- whether or not it is thought to represent a novel occurrence, such as a disease caused by a new pathogen or a disease in a new geographical area.

The use of decision trees can help communities determine which events need urgent high-level responses (e.g., a case of hemorrhagic disease) and those that can be investigated and handled at a lower level (e.g., a rabid dog).

As with IBS, EBS systems should be linked to existing response mechanisms such that events are responded to appropriately and in a timely manner. Response efforts may include field investigation, deployment of a Rapid Response Team (RRT), laboratory testing, immunization campaigns, and appropriate infection control and prevention measures. As EBS facilitates the detection of all hazards, events detected may not necessarily be limited to infectious diseases, and response will require the involvement of stakeholders in multiple sectors.

Definition, Use, and Prioritization of Signals in Event-Based Surveillance

When defining signals for use in an EBS system, it is important to consider the elements of sensitivity and specificity to find the right balance between the two. The use of highly sensitive signals that try to capture too much can overburden surveillance systems and result in excessive signal noise, obscuring the appearance of true events. Alternatively, overly specific signals may reduce the ability of EBS to capture all events. Achieving the right balance may require piloting and revision of signals before they are finalized.

Signals should also be country- or region-specific and tailored to the specific concerns of the context in which they are used. As a first step, diseases and events of interest or concern, including non-infectious disease events (i.e., "all hazards" events), should be prioritized. This prioritization process should be conducted in consultation with all EBS stakeholders through multisectoral collaboration.

Moreover, the process of signal selection should be flexible and dynamic, and readily amenable to additions or deletions as the need arises. The list of events should also be relevant to the source (i.e., in community or health facility settings). For example, seasonal diseases such as dengue and seasonal influenza may be best detected though IBS in health facilities rather than through CBS, while the detection of foodborne illnesses can be relevant in both settings.

Sources for Event-Based Surveillance included in the Training Curriculum for Event-Based Surveillance in Health Facilities and Communities

EBS requires a multisectoral approach and relies on sources of information beyond traditional health system sources. Some of the most commonly used EBS sources include health facilities, laboratories, communities, traditional healers and media, among others. This section highlights the EBS sources included in the *Training Curriculum for Event-Based Surveillance in Health Facilities and Communities*.

Health facilities

Besides being a crucial source of information for the more traditional IBS, health facilities are an important source for EBS. Cases requiring immediate reporting are essentially events under the EBS working definition that may signal a larger problem needing immediate response. Limiting event reporting from health facilities to those that have recognized or suspected etiologies (i.e., reporting using disease-specific case definitions) limits the usefulness of the system. Defining signals for immediate reporting beyond a list of notifiable diseases can improve the sensitivity of the early warning system and emphasizes the role of health facilities in EBS. A recent example of this was the case of Middle East Respiratory Syndrome (MERS) that was first reported as a signal in Jordan many months before the disease was recognized. Examples of signals for use in EBS in health facilities include a sudden increase in admission of cases with similar signs and symptoms; a case with unusual presentation or clinical course; or a health care provider (or group of providers) who develops acute illness after caring for similarly ill patients. An additional type of signal using health facility data involves the definition of alert thresholds in these data, especially for common seasonal diseases.

For the management of EBS, each health facility may consider nominating a focal point to receive the signal reports from the healthcare workers in that facility. Existing surveillance focal points may also carry out this role. In order to serve its purpose and be as representative as possible, EBS should count on the contribution and participation of every health facility in a given area, including public and private facilities. Once a list of signals is identified for health facilities, all healthcare workers should be routinely sensitized to look for, and immediately report, anything unusual to their focal points using the available list of signals (see examples in Table 1). Every focal point should participate in EBS training to support healthcare workers and be responsible for immediate reporting of signals to intermediate-level public health authorities through predefined and structured reporting mechanisms. These authorities are then responsible for the triage, verification, and risk assessment of signals reported from health facilities.

Table 1. Examples of signals for health facilities

1. Severe illness requiring hospital admission in health care workers after caring for patients with similar symptoms
2. Large, unexpected, sudden increases in admissions for any illness of the same type, including patients in intensive care units
3. Severe, unusual, unexplainable illness including failure to respond to standard treatment

Community-Based Surveillance

The importance of the CBS platform in EBS lies in its ability to detect events before they become widespread and apparent to healthcare workers.

EBS at the community level can be conducted by community health workers (CHW), community health volunteers (CHV), or a local level public health office working through key informants in the community. CBS programs need active engagement from the public health unit at the local administrative level to successfully maintain a network of key informants. Public health authorities within the local public health unit can supervise the CHWs in their geographic area. Where local public health units do not exist, nurses or doctors in primary health facilities may serve as local level supervisors for CHWs. In any case, workers at the local level are the first responders to signals detected through CBS, and are responsible for triaging, verifying, and reporting signals to designated public health authorities at the intermediate level. They should also encourage the CHWs, CHVs, and key informants with regular feedback and refresher training, where necessary.

Key informants are community members who have a strong relationship with their communities and can include traditional healers, village/community leaders, members of women's groups, agricultural unions, shop owners, and priests. Other key informants might include representatives from educational institutions, factories, farmers unions, and pharmacists. Key informants can be very helpful in limiting signal noise that may occur if reporting is expanded to include the entire community.

Signals defined for CBS need to be simply worded without technical jargon, to allow for greater understanding and effective use by key informants who may have no medical training or background. The table below shows an example of a signal list for the community.

Table 2. Examples of signals for communities

1. Any child less than 15 years old:

- With sudden weakness of limb(s)
- With fever and skin rash

2. A single case severe enough to require admission to hospital or causing death of any of the following:

- Three or more rice watery stools in 24 hours with dehydration (fatigue, thirst or sunken eyes)
- A respiratory infection with fever in someone who has been traveling abroad in the last 14 days
- Illness after contact with sick or dead animals
- Illness with fever, watery diarrhea and unexplained bleeding (gums, skin, or eyes, stool or urine)

3. Two or more hospitalized cases and/or deaths with similar type of symptoms occurring in the same community, school or workplace in the same seven-day period, especially:

- With high fever, stiff neck
- With high fever, yellow eyes or skin

4. Unexpected large numbers of:

- Deaths of poultry or other animals
- Children absent from school due to the same illness in the same seven-day period

5. Any event that poses a risk to public health, including natural disasters, or symptoms / diseases rarely seen in the community

Other Sources for Event-Based Surveillance

Animal health sector

Most countries may have animal health surveillance and response systems that are parallel to the human health system and collect information from the community through animal health workers, wildlife health laboratories, and veterinary clinics, among others. Connections need to be established between human and animal health sectors at each administrative level, corresponding to the source of signals in EBS. For example, CHWs might be the first in a community to be aware of a die-off of a backyard poultry flock, or exposure to a rabid dog, and should be trained to notify their animal health counterpart. Animal health workers who detect similar signals that may impact human health should notify their CHW counterpart as well. Signals of animal disease that may be important to a human EBS program can involve the detection and reporting of animal events such as unusually high rates of abortions in goats, or the sudden death or signs of hemorrhage in domestic and wild-hooved mammals or migratory bird flocks. Diseases or patterns of illness in animals that might represent a threat to human health should be notified to public health authorities as events. This is especially true of zoonotic diseases like rabies, anthrax, and brucellosis, which can be passed between animals and humans. There should also be cross-reporting of events between animal and human health systems that may have long-term negative consequences on human well-being, such as animal diseases like African swine fever that can decimate animal populations, impacting both food security and trade. These would, however, be reported through other mechanisms outside of EBS, such as information sharing at the national administrative level.

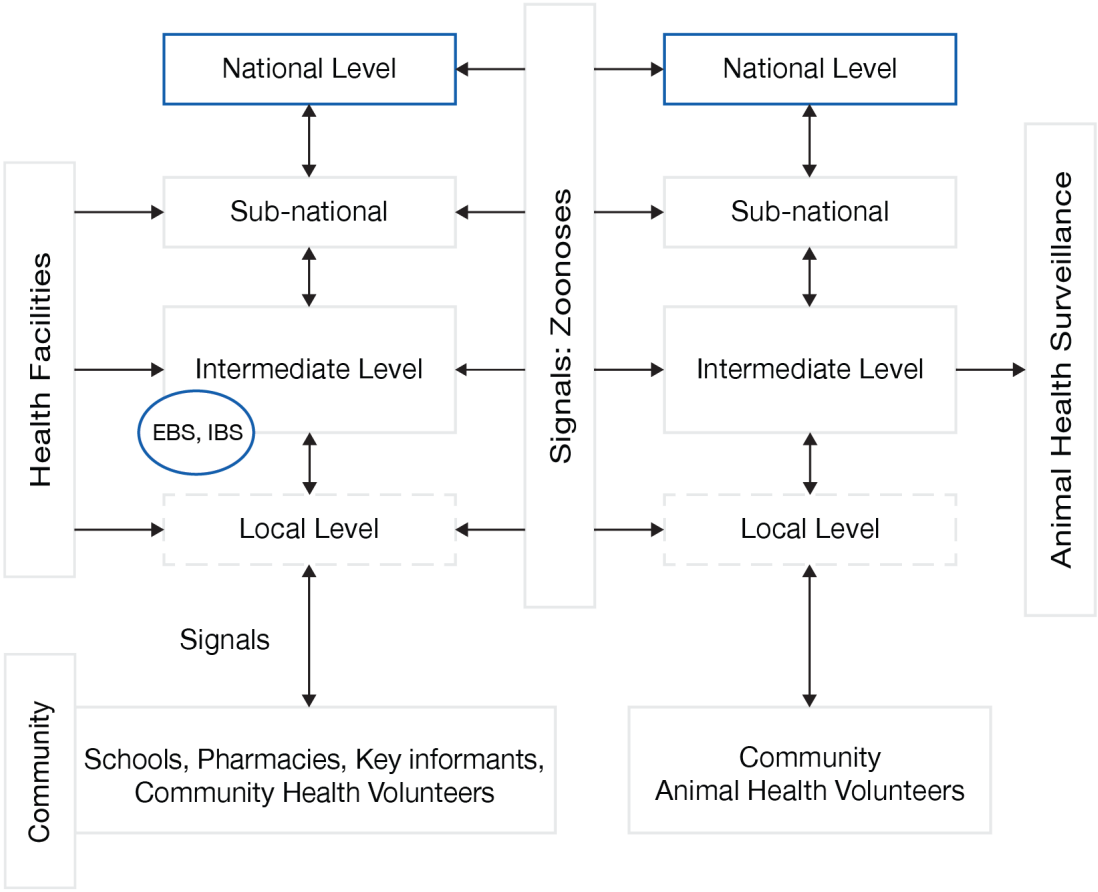
It would thus be important for countries to consider designing a list of signals for recognizing zoonotic events for the conduct of EBS (see Table 3).

Table 3. Examples of signals for the animal health sector

1. Severe illness in veterinarians, wildlife staff, or community members after contact (culling, feeding, treating, vaccinating) with a sick or dead animal
2. Large, unexpected, sudden increases in disease or death of animals
3. Sudden increase in abortions in animals
4. All immediately notifiable zoonoses

Once the list of signals is available, both animal health workers and CHWs should be trained to recognize and immediately report to public health authorities at the relevant administrative level. In countries that have a well-organized animal surveillance system, signals and events can be communicated at every level between the animal health and human health sectors from the local to the national level (see figure below). Additionally, there should be mechanisms in place at the national level, and if resources allow, at the intermediate level for immediate notification of zoonotic events by both sectors. Such mechanisms should also enable joint responses to be conducted.

Figure 4. Importance of cross-reporting between human and animal sectors in EBS



Monitoring media and other electronic sources

Media monitoring is the process of tracking media coverage with the aim of early detection of signals with potential public health impact. With the explosion of information on the Internet, monitoring information that is freely available in online media and other electronic sources has become an important source of epidemic intelligence that can be implemented at the national level, and at other sub-national levels where resources exist. Monitoring media and other electronic sources can be a useful supplement to the community, health facility, and intermediate level components of the EBS system and can be useful to monitor the course of an event. Electronic sources can be either official (e.g., Ministry of Health, Agricultural, or other Ministry websites) or unofficial (e.g., newspapers, social media, and blogs). As with other EBS strategies, signals from media sources must be defined, and once reported, triaged and verified.

Several tools for monitoring media and other electronic sources are available at no or limited cost. The Global Public Health Intelligence Network (GPHIN), one of the earliest programs to automate media scanning, was developed by the Public Health Agency of Canada in partnership with WHO in the late 1990s and is a useful free tool for this activity. In addition, there are now several other aggregator systems that provide moderated content such as ProMed and HealthMap that are useful to monitor global events. There are also aggregator systems such as MediSys that work by searching thousands of news media and other online information sources in multiple languages and identifying signals through keyword matches with predefined search terms. Most recently, WHO, in collaboration with the European Union, created a "system of systems", the Epidemic Intelligence from Open Sources (EIOS) system, that pulls together existing epidemic intelligence aggregator systems and incorporates additional sources and categories customized to meet the needs and priorities of individual user communities (i.e., by country or organization). While not yet employed and accessible universally, EIOS will allow for the use of Boolean search terms and filters that can be user-defined, and a variety of machine learning techniques to score articles by relevance. The media monitoring team is an interdisciplinary group of analysts who perform scanning of open sources of information on the web, triage and verification of potential signals, and risk assessment of events.

A training curriculum that prepares public health practitioners to carry out EBS through the monitoring of media and other electronic sources has been developed and published by the U.S. Centers for Disease Control and Prevention's Global Disease Detection Operations Center in collaboration with Georgetown University's Center for Global Health Science and Security. These materials are available at: https://ghss.georgetown.edu/ebs/.

Hotlines and toll-free numbers

Existing hotline and toll-free number systems have been employed and leveraged to incorporate the reporting of signals, both from members of the community and healthcare workers. They have also been designed to receive signal reports through SMS and other messaging applications such as Facebook Messenger, Twitter, and WhatsApp. A monitoring team should be trained on the list of priority signals and the use of standard data collection tools, to ensure that the minimum information needed for triage and verification is collected. All received information should be registered into a signal database to continue the process of triage and verification as previously outlined in this module.

Notably, hotlines were used during the Ebola outbreak in West Africa in 2013-14, during which they were open to the public to report suspected Ebola virus disease cases or deaths 24 hours per day. However, hotlines present several limitations and need to be optimized to overcome some challenges, including difficulty in localizing callers when calls are received at a central facility and generation of large amounts of signal noise in the system attributable to overreporting of unverified signals by the general public. They also can raise the expectations of the general public that some action will be taken as a result of the reporting, ultimately resulting in dissatisfaction when these expectations are not met. One method to address some of these issues is to limit use to a select group of key informants and public health professionals.

Laboratories

In laboratories, signals take the form of the detection of pathogens that are immediately notifiable (e.g., the detection of Ebola virus in a clinical sample) and unusual patterns of detection (e.g., a sudden increase in a pathogen detection in a given time period, detection of a rare pathogen from body fluids (e.g., fungi from sterile body fluids), detection of multi-drug resistant pathogens, clusters of specific organisms, and unexpected increases in the detection of organisms from unusual places). All public and private laboratories should report notifiable diseases and other signals to public health authorities and contribute to EBS.

Table 4. Examples of signals for laboratories

1. A pathogen that has not been detected for a long time in that country or a new pathogen
2. Large/sudden unexpected increase in numbers of specimens with the same testing request, or positive result for the same pathogen (including the pathogens that are resistant to multiple antibiotics)
3. Any pathogen on the immediately notifiable list
4. Un-subtypeable or new influenza strain from a patient with Severe Acute Respiratory Infection (SARI)

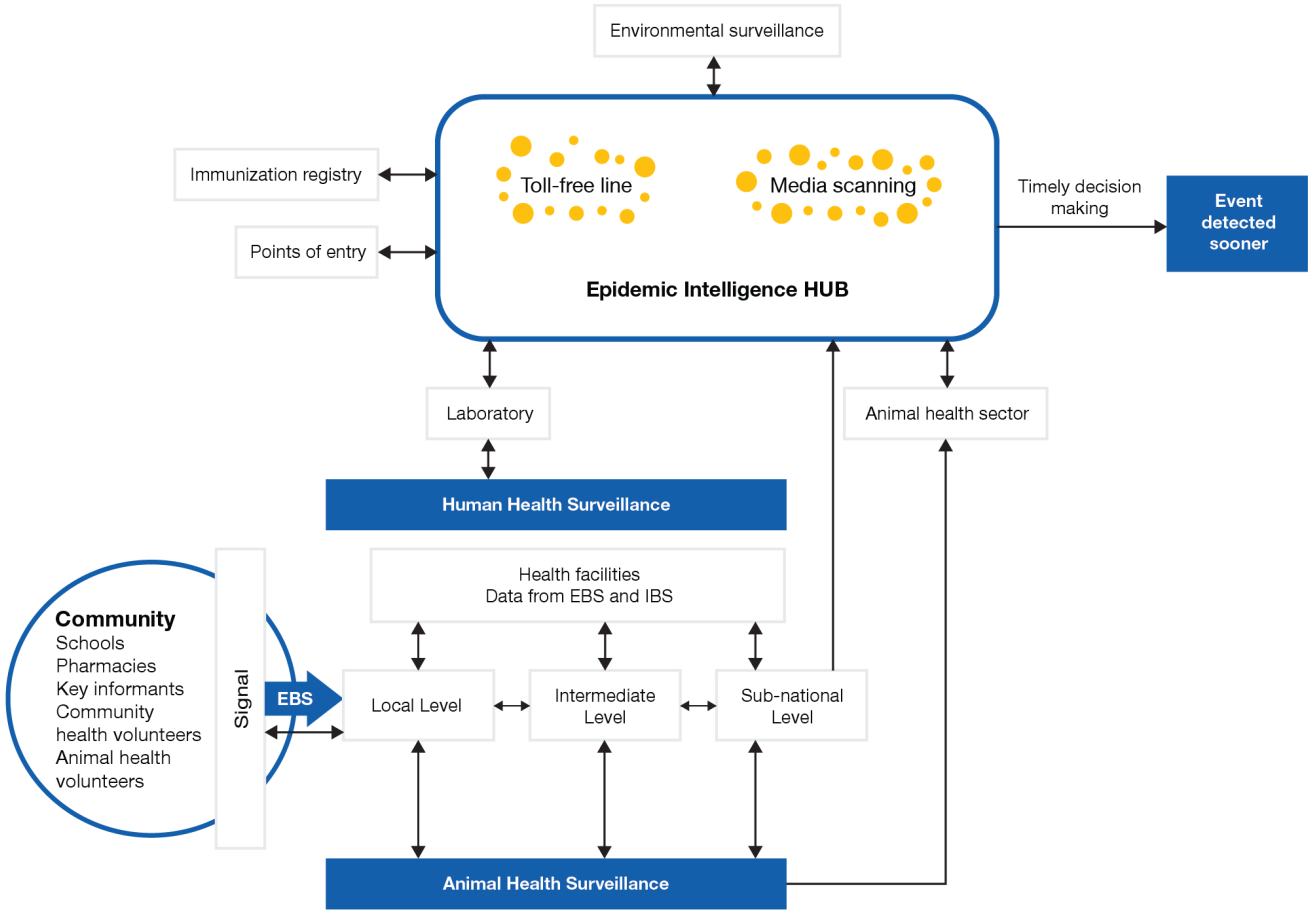
Other sources

Events can originate from other sectors such as educational institutions, military hospitals, other specific surveillance systems such as those for border health, and environmental sectors. It is not necessary that these sectors share all the information/data that they are collecting with the human health sector – only data or signals that may predict human health events. As with other sources described above, these sectors can share relevant data based on a predetermined list of signals.

Epidemic Intelligence Data Hubs

It may be useful to establish an epidemic intelligence hub nationally (and sub-nationally) with the capacity to receive, interpret, and visualize surveillance data from multiple sources and in multiple formats. This hub would ideally receive structured data collected through IBS systems; verified events from EBS systems that include animal events from the animal health sector; data from immunization registries, environmental sectors, and other sectors; and media and scientific publications. By receiving this information, the data hub could facilitate the quick identification of any event which may threaten the public's health (see figure below).

Figure 5. Possible functioning of an epidemic intelligence hub



In these data hubs, data streams could be integrated and displayed on dashboards using automated routine analyses to improve accessibility and utility of the surveillance data. Many countries now have Public Health Emergency Operation Centers (PHEOC) that serve as data hubs for epidemic intelligence. Having all of the data together facilitates the work of trained analysts who evaluate and synthesize the data that are provided to decision-makers and responders.

Conclusion

Recent history has demonstrated the consequences of late detection of public health events. The need to detect emerging and re-emerging diseases and public health events early is essential for rapid response and containment, having a direct impact on the security of the public's health. The EWAR framework outlines how information from both IBS and EBS can enable the early detection of, and response to, public health events. While data from IBS is restricted to mainly formal sources of information within a surveillance system, data from EBS can come from numerous, diverse sources. In this all-hazards approach, EBS can facilitate the early detection and rapid reporting of emerging public health events.