Infectious disease surveillance and global security

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CHAPTER 17

Introduction

Current state of global, regional and national disease surveillance

The World Health Organization (WHO) serves as the universally recognized steward for global health with a mandate from the United Nations (UN) and all 195 member states to coordinate global health efforts including disease surveillance and outbreak detection and response [1]. The WHO relies on numerous tools to implement its mission, including binding treaties such as the International Health Regulations (IHR) [2]. The new guidelines were significant in that they increased the visibility of public health within the greater global foreign policy and diplomatic communities. Despite unanimous agreement to comply with the IHR, most UN member countries do not yet have the capability to detect, analyze, report, and respond to an outbreak of a disease with the potential to spread globally, commonly referred to as a Public Health Emergency of International Concern (PHEIC) [2]. To date, only 30 member states have claimed the full capacity to comply with the IHR [3].

In 2000, WHO created an operational response unit called the Global Outbreak Alert and Response Network (GOARN) with the primary goal of improving global health security [3]. The WHO itself does not possess the numbers of technically trained personnel that would be required to meet this goal, so it relies on a voluntary network of institutions and personnel organized through the GOARN operational framework. The GOARN works to prevent the international spread of epidemics by assuring that the correct technical expertise is provided to a location in need in a timely fashion helping to build sustainable response capacities on the local level. Members of the GOARN include laboratory networks, scientific institutions in UN member states, surveillance networks, UN organizations such as UNICEF, and medical nongovernmental organizations such as Medecins sans Frontieres. The GOARN has established Guiding Principles that describe expectations for preparedness and response to epidemics, as well as procedures that attempt to standardize operations. The GOARN network has demonstrated its effectiveness in responses to over 50 events in 40 countries, including the SARS epidemic, H5N1 avian influenza outbreaks, and several cholera outbreaks around the world [4].

The WHO’s headquarters is located in Geneva, Switzerland, but many public health activities are delegated to regional offices. These regional offices are: the Regional Office for the Americas, also known as the Pan-American Health Organization (PAHO), in Washington, DC, United...
Methods used in surveillance and data analysis

States; the Regional Office for Europe (EURO) in Copenhagen, Denmark; the Regional Office for South-east Asia (SEARO) in New Delhi, India; the Western Pacific Regional Office (WPRO) in Manila, Philippines; and the Regional Office for Eastern Mediterranean (EMRO) in Cairo, Egypt [1]. The capability of these regional offices depends on the commitment of the countries in the region and their relationship with WHO headquarters.

A limited number of organizations with financial resources and regional governance structures that allow for such activities also conduct regional disease surveillance. Among these are the European Center for Disease Prevention and Control (ECDC) and the Asia Pacific Economic Council’s Emerging Infections Network (APEC EIN) [5,6]. The ECDC was established in 2005 by the European Union to strengthen defenses against contagious infectious diseases in Europe through comprehensive disease surveillance and early response to potential threats. In addition to surveillance and response activities, ECDC provides timely and relevant data and technical expertise to the European Union countries. The ECDC was crucial in the response to the recent outbreak of *Escherichia coli* O1:O4 that led to hemolytic uremic syndrome in Europe because of contaminated food. Other regional networks such as APEC EIN are less formalized and more narrowly focused on emerging infections and their impact on trade [6].

Role of the military in global infectious disease surveillance

Other organizations with longstanding interest in disease surveillance are the world’s militaries. Timely detection of new diseases and epidemics is important to protect military personnel. It is also a key requirement for global public health security, increasingly recognized as crucial to stability. Timely detection of disease outbreaks requires adequate infectious disease surveillance, the ability and willingness to report to global public health authorities, and a meaningful mechanism for providing response to control an outbreak. The global presence of militaries in support of peacekeeping or strategic missions makes this requirement more relevant for the military, especially when reporting of potential disease outbreaks among personnel in a foreign country is required. Additionally, military, government, and nongovernmental personnel dispatched around the world have a special responsibility to prevent the spread of contagious diseases through their travels. In the past, militaries have inadvertently contributed to the spread of infectious diseases, including influenza during the 1918–1919 pandemic and, more recently, cholera in Haiti [7]. Because of this reality and the recognized responsibility to the overall public health, militaries continue to make significant contributions to global infectious disease surveillance efforts, often in direct support of the IHR mission [8]. As discussed later in this chapter, the United States Department of Defense supports development of electronic systems to facilitate disease reporting within partner host countries [9].

U.S.-based global disease surveillance

Global Disease Detection Program

The Centers for Disease Control and Prevention (CDC) has a major role in disease surveillance and response throughout the world. Initially charged with a domestic responsibility, CDC over time has developed an increasingly global presence. The Global Disease Detection Program and Emergency Response (GDDER), begun in 2004, is CDC’s lead initiative for developing and strengthening global capacity to rapidly detect, accurately identify, and promptly contain emerging infectious disease and bioterrorist threats that occur internationally [10]. The GDDER was created to “mitigate the consequences of a catastrophic public health event, whether by an intentional act of terrorism, or the natural emergence of a deadly infectious virus” [10]. CDC approaches its mission of improving global health security through building cooperative partnerships. The GDDER program was designated as the first WHO Collaborating Center for Implementation of International Health Regulations, National Surveillance and Response Capacity [10]. In this role, the GDDER program partners with Ministries of Health, WHO, and already established CDC programs to improve core public health capacities in developing countries targeting early identification and control of emerging infectious diseases. Some of these established programs include the influenza surveillance network, field epidemiology and laboratory training programs emerging infections and zoonotic disease surveillance, laboratory
Over the period 2006–2011, the GDDER regional centers have responded to more than 900 outbreaks around the world. Provided at the request of the host government, this support is especially important for countries with limited resources or in countries experiencing outbreaks caused by dangerous pathogens such as Ebola virus, Marburg virus, SARS, or Nipah virus. In 2011, the GDD program was responsible for detecting seven pathogens new to their region and three organisms that were new to the world [10].

Much of the value of the GDDER program is realized through building public health capacity in host countries and regions (Figure 17.1). Centers are currently located in Bangladesh, China, Egypt, Georgia, Guatemala, Kazakhstan, Kenya, India, South Africa, and Thailand. Several of these grew from existing CDC activities. For example, the laboratory in Guatemala was founded in 1978 as a parasitic diseases research center. Other GDDER centers have built strategic partnerships such as with the International Centre for Diarrheal Disease Research in Bangladesh (ICDDR, B) and the Naval Medical Research Unit 3 (NAMRU-3) in Cairo, Egypt. The most recent GDDER sites include collaborations in China and South Africa, two additional hot spots in terms of emerging infectious diseases. Sites are chosen in close consultation with the host countries and WHO; new sites are planned but their realization depends, largely, on availability of funding.

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**Global Emerging Infections Surveillance and Response System**

The U.S. Department of Defense (DoD) created the Global Emerging Infections Surveillance and Response
System (GEIS) in 1997, soon after a presidential decision directive (PDD-7) mandated that all agencies within the government increase capabilities to detect and respond to global emerging infectious diseases [11]. Through this program, the DoD created a global network based on regional surveillance efforts utilizing DoD overseas medical research laboratories that had been working with host countries for decades on infectious diseases of common interest. These laboratories work side by side with host country scientists in Egypt, Cambodia, Peru, Thailand, Kenya, and numerous other countries. (Figure 17.2). For example, the Naval Medical Research Unit Three (NAMRU-3) based in Cairo, Egypt, was first established to confront typhus during World War II. Over the ensuing decades, the success of NAMRU-3 in this initial control program led to broad infectious diseases research and surveillance initiatives that were mutually beneficial to both countries.

One mission of the GEIS program is to develop, implement, support, and evaluate an integrated global emerging infectious disease (EID) surveillance and response system. Protection of U.S. and allied service members is also a strategic focus. Equally important and well aligned with its primary focus of global public health security is the recognition that adequate health allows for country-level security and, thus, contributes to regional stability—one of the stated strategic goals of the DoD and the U.S. government [12]. By 2012, the GEIS network included 33 partners in 76 countries (Figure 17.2). Key partners continued to be the five DoD overseas research laboratories, each of which has numerous collaborations in their respective regions in Southeast Asia, Africa, the Middle East, and Latin America. The GEIS program has also supported reference laboratories that develop and test diagnostic assays for deployment overseas in addition to conducting disease surveillance in military and nonmilitary associated populations within the United States.

Today, medical research laboratories established by U.S. military are vital to infectious disease surveillance efforts in host countries. Despite political and social strife during the past 60 years, NAMRU-3 remains active in face of infectious disease threats such as avian influenza (influenza A/H5N1). The U.S. Army Medical Research Unit–Kenya (USAMRU–K) has also collaborated in surveillance efforts with national ministries of health and defense for over four decades. The collaborative research partnerships in each of these settings have been responsible for numerous scientific discoveries concerning emerging and tropical infectious diseases,
including the isolation of novel pathogens, the first description of artemisinin-resistant Plasmodium falciparum, and several reference strain contributions to Northern and Southern hemisphere influenza vaccines (including the seed strain for the 2009 influenza A/H1N1 virus) [11].

**Case studies**

**Influenza surveillance**

Influenza is one of the leading causes of annual morbidity and mortality from respiratory infections globally, accounting for up to 500,000 deaths per year throughout the world [13]. It is the pandemic potential from genetically shifted novel strains, however, that drives the interest in monitoring influenza infections. The 1918 influenza pandemic caused more deaths than any other pandemic in recorded history, with some authors estimating that over 50 million deaths occurred worldwide [14]. The most recent pandemic occurred in 2009 but it did not result in a significant increase in mortality.

**Global Influenza Surveillance and Response System**

Coordinated global influenza surveillance has been conducted since 1952 through WHO [15]. In 2013, the Global Influenza Surveillance and Response System (GISRS) consisted of six WHO Collaborating Centres, four Essential Regulatory Laboratories (ERLs), and over 140 institutions in more than 100 countries (Figure 17.3). Influenza samples are collected through various sampling schema that depend on the public health systems of individual WHO member states. These...
samples are processed at one of the National Influenza Centers (NICs), and isolates are then forwarded to one of the WHO Collaborating Centers for further analysis and comparison with other isolates from the region and around the globe. The scale of genetic (genotypic) and antigenic (phenotypic) differences among the influenza strains indicates the potential for pandemic spread. Any novel viruses discovered are considered for inclusion in the annual influenza vaccine preparations.

The global influenza virus surveillance process occurs on a continuous basis throughout the year. Vaccine preparations are updated annually, with each vaccine typically including one strain of influenza A/H3N2, one influenza A/H1N1, and one influenza B. Distinct Northern and Southern hemisphere vaccine preparations may be offered, depending on the expected circulating influenza strains and the seasonality of the respective temperate regions. In addition to vaccine strain selection, the GISRS monitors burden of illness related to influenza-like illness (ILI) and severe acute respiratory infections (SARI), as well as influenza virus susceptibility to medications such as oseltamivir.

**The Department of Defense GEIS program**

The DoD GEIS program in collaboration with CDC identified the first four cases of the pandemic 2009 influenza A/H1N1, conducted influenza A/H1N1 diagnostic training in over 40 countries, and assisted in the first diagnosis of the virus in 14 countries [10]. These efforts are facilitated through partnerships with the host countries. As mentioned above, one of the key components of both the GDDER and GEIS programs is their emphasis on building capacity at the host-country level, which includes the support of NICs.

**Challenges in influenza surveillance**

Influenza surveillance is not without controversy. There has been concern that sharing data and viral isolates from disease surveillance activities has not resulted in equitable benefits for countries with limited resources (mainly with respect to access to vaccines and antiviral medications) commensurate with their contributions [16]. This concept of viral sovereignty has undermined trust and transparency and, thus, global disease surveillance and global public health security. A recent major diplomatic impasse lasted for 4 years, during which time several countries did not share viral isolates with the GISRS. At the May 2011, the World Health Assembly, a Pandemic Influenza Preparedness (PIP) Framework for influenza virus sharing, benefits sharing, and standard material transfer agreements was drafted and agreed upon (WHA 60.28) by key member states, industry partners, and the WHO [17]. There remain underlying issues regarding institutionalization of data and sharing of samples but at present, all 195 member states theoretically contribute to the GISRS.

**Electronic disease surveillance**

The state of electronic disease surveillance has changed drastically worldwide since the late 1990s. The advent of both the Internet and mobile health (mHealth) technologies has enabled the public health community to collect and transmit data much more readily than in the past. This new capacity, although groundbreaking for public health professionals, has also come with challenges. For example, now that the public health community has more data available to them, methods must be developed to collect, store, analyze, and disseminate this data in a timely, efficient manner. These very issues have presented numerous hurdles in the developed world and are more acute in resource-limited countries.

Prior to the terrorist attacks in the United States on September 11, 2001, electronic disease surveillance systems were in the early stages of development, with the CDC and many health departments relying on short-term, drop-in surveillance for large events and mass gatherings. These systems were labor intensive and often required personnel in emergency departments to examine patient logs at recurring intervals for a set period of time before and after events in order to provide data to public health officials. Given this process, these types of systems were not sustainable for extended periods.

**Electronic Surveillance System for the Early Notification of Community-based Epidemics**

Today, most health departments in the United States rely on electronic systems that acquire process, analyze, and visualize validated data sources such as emergency
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department chief complaints, physician diagnosis data, over-the-counter medication sales, and poison control center data for assessing community health. One such system is the Electronic Surveillance System for the Early Notification of Community-based Epidemics (ESSENCE), which is currently in use by many U.S. state and local health departments, by the U.S. military, and the U.S. Veterans Health Administration [18].

**Early Warning Outbreak and Response System**

During the early years of system development and adoption in the developed world, similar efforts were underway in countries with fewer resources. The Early Warning Outbreak and Response System (EWORS) was developed in conjunction with one of the U.S. Navy overseas labs for use in a number of Southeast Asian countries. This system was based in civilian urban hospitals and required clinicians to identify patients with possible infectious diseases and to manually complete a questionnaire. These questionnaires were then entered into an on-site computer and transmitted via email to a central EWORS hub. In Peru, with the assistance of the regional U.S. Navy lab, the Peruvian Navy developed a surveillance system that relies on providers using a phone to enter patient information via an interactive voice response (IVR) system. Both of these systems were instrumental in the evolution of electronic disease surveillance systems in that they highlighted the potential of such systems and identified areas where technology could vastly improve the process [19].

The biggest limitations to the development and sustainment of electronic disease surveillance systems, particularly in resource-limited countries, are the ease with which data are collected, accessed, and used by public health officials. Systems that require large amounts of resources, whether that is in the form of the workforce or information technology (IT) infrastructure, will not be successful in the long term. Successful systems run on existing hardware that can be maintained by modestly trained IT professionals and are easy to use by end users in public health [20].

**Suite for Automated Global Electronic bioSurveillance System**

To develop a successful system, careful consideration must be paid to data collection, analysis and visualization, information sharing, and system evaluation. One system that has developed a “toolkit” approach is the Suite for Automated Global Electronic bioSurveillance System (SAGES) based upon the civilian ESSENCE system. One or more SAGES tools may be used in concert with existing surveillance applications, or the SAGES tools may be used en masse for an end-to-end biosurveillance capability. This flexibility allows for the development of an inexpensive, customized, and sustainable disease surveillance system. The ability to assess anomalous disease activity rapidly may lead to better compliance with IHR (2005) [21].

Data can be as simple as raw text of individual patient encounters and as complicated as information gathered by way of detailed analysis or end user interpretation [22]. In countries with reliable Internet connectivity and sophisticated healthcare and inventory systems, data can be acquired through mechanisms such as Health Level 7 (HL-7), secure file transfer protocol (sFTP) or email [23]. In countries with limited resources, there is a need to capture data from remote settings that lack these means of data transfer. Therefore, it is imperative to utilize mobile collection platforms, such as cell phones, which are ubiquitous throughout much of the world (Figure 17.4). The complexity of data collection via cell phones will depend on infrastructure. For example, in areas lacking high penetration of smart phones, a simple texting protocol can be utilized. In areas where smart phones are readily accessible, one may opt to use forms via the phone. These forms can be submitted via short message service (SMS); the use of forms minimizes the potentials for error. One area that requires additional consideration is the security of data transmitted via SMS. Although patient privacy laws vary greatly throughout the world and personally identifiable information is not currently being collected in most systems of this type, there can be sensitivities based on the organization using the data and the type of diseases under surveillance [20].

**Practical considerations for electronic surveillance systems**

Once data are collected, they should be aggregated, analyzed, and presented in a way that allows the end user to determine quickly whether additional actions are warranted. Use of algorithms can further facilitate statistical anomalies that alert end users, at predefined
time intervals, of potential problems that require further investigation. Indeed, many automated systems now allow end users to directly query their data and determine whether there are concerns. For example, if a novel respiratory condition, such as SARS, emerges, the system end user can query for a particular case definition, run detection algorithms, and determine whether further investigation is warranted [23]. Many algorithms are available for analysis of data collected by a variety of systems including the open source CDC Early Aberration Reporting System (EARS) and SAGES. Visualization is just as important as the alerting components of a system. Feedback from users has demonstrated that visual data presentation (e.g., with time series, charts, maps, and line listings) is important in understanding a given situation. It also allows end users to share such information with the decision makers and public health colleagues in neighboring jurisdictions or countries. Typically, decision makers would be public officials authorized to approve public health response measures. Capabilities that aid in information sharing includes the ability to export data into other file type such as map images as pictures and data listings as spreadsheet [21].

Once a system has been operational for a period, it is very important to evaluate the system to ensure it is working as intended and is assisting the public health end users in doing their jobs as efficiently as possible. Factors to consider include the frequency of data dropouts, the amount of time it takes for people in the field to input the data, and the time required to maintain the supporting IT infrastructure. Ideally, the system will also aid in improving public health outcomes by enabling public health officials to identify and respond to
a potential outbreak earlier than they would have otherwise.

**Challenges in disease surveillance for global security**

Achieving comprehensive disease surveillance on a global scale is a complex proposition. The challenges are myriad and include local, national, regional, and global issues. Governance of a global disease surveillance system is complex, especially as the WHO faces fiscal constraints and a fluctuating global leadership role [24]. To meet the requirements for IHR compliance with the ultimate goal of optimizing global public health security, public health practitioners at all levels must understand these challenges. [25].

Global public health has increasingly been recognized as a foreign policy concern, and this has introduced a new set of power brokers into the public health arena including those normally associated with diplomacy, public policy, economics, and national security [26]. The newly added dimensions of politics and security sometimes engender perceptions of “intelligence gathering” on the part of WHO and other agencies. Some have decried this “securitization of public health,” citing this as unnecessary and potentially damaging to public health efforts. This perspective, however, has been central to the WHO since its inception, with its constitution stating that the “health of all peoples is fundamental to the attainment of peace and security” [2]. The IHR framework supports global health security with less emphasis on borders and more on cooperative action where needed[27]. Through effective global disease surveillance, timely detection of outbreaks, and appropriate response to control the spread of epidemics, the outcome of “global health” is thereby a significant component of “global security.”

Knowledge is power; and when knowledge has the potential to impact national or international affairs, data sharing may become difficult. This became clear with the cessation of influenza virus sharing with GISRS by several countries with limited resources. Complete and transparent data sharing is likely an unobtainable ideal. It is more likely that countries would share some information after data analysis to meet their moral obligation to the international community. However, in some countries, public health have expressed reluctance in compliance with IHR citing common but less-contagious diseases as higher priorities [28].

Because of the potential for rapid spread of contagious disease, effective disease surveillance should ideally be comprehensive. Unfortunately, this is hardly feasible in many countries with limited resources. Under Article 44 of the IHR, developed countries have an obligation to assist lesser developed member states with obtaining and maintaining the necessary capabilities. Sustainability of these surveillance capabilities once established is a key consideration; and successful solutions will likely include novel methods of financing such as cost sharing between donor countries, industry, and host-country governments. Standardization of surveillance data is also challenging. Ideally, both epidemiologic and laboratory data related to disease surveillance will be comparable among member states, but standardization of these data is not without controversy. Each member state has specific laws and requirements that are dependent on availability of funding and access to technology. Efforts through Article 44 of IHR are attempting to improve sustainability of surveillance through improving standardization [3].

Finally, having a well-trained public health workforce remains an obstacle to optimal surveillance in many countries. Efforts to improve this “human” capacity include programs such as the CDCs FELTP, as well as shorter training programs in outbreak management [29].

**Conclusions**

Maintaining global health security is a complex and challenging endeavor—one that affects all citizens of the world. The persistent threats to public health security from all continents mandate that each country contribute to the common good through efforts such as health surveillance. All sectors of society from doctors and scientists to the military and politicians must play a role in these surveillance efforts, which will likely include traditional epidemiologic methods and novel techniques, such as the use of mobile phones, for reporting and genetic sequencing of outbreak-related strains.


**STUDY QUESTIONS**

1. Give an example a global disease surveillance system coordinated by the World Health Organization, and describe briefly how this system contributes to public health response to outbreaks.

2. Briefly describe the role of the United States Department of Defense in global surveillance.

3. Identify and briefly describe two examples of electronic surveillance systems.

4. Give an example of a practical limitation in implementation of electronic disease surveillance systems in settings with limited resources, and discuss a possible solution.

5. Public health emergencies (e.g., pandemics) are global threats to security. What are some of the arguments for and against this perspective?

6. Sustainability is always a concern for externally funded public health programs. In your own opinion, what are some of the reasons why medical research laboratories established by US military (e.g., in Egypt and Kenya) have remained active for decades?

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**References**


