Trends and Directions of Global Public Health Surveillance

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Recently, global health and global health surveillance have received unprecedented recognition of their importance because of the newly emerging and reemerging infectious diseases, new cycles of pandemics, and the threats of bioterrorism. The aim of this review is to provide an update of the current state of knowledge on health surveillance in a globalized world. Three key areas will be highlighted in this review: 1) the role of the new International Health Regulations, 2) the emergence of new global health networks for surveillance and bioterrorism, and 3) the reshaping of guidelines for the collection, dissemination, and interventions in global surveillance. A discussion is also presented of the more important challenges of global health surveillance.

Global surveillance has been reshaped by important changes in the new International Health Regulations and the rapid development of new global networks for disease surveillance and bioterrorism. These networks provide for the first time at the global scale real-time information about potential outbreaks and epidemics of newly emerging and reemerging infectious diseases. The recent outbreaks of severe acute respiratory syndrome (SARS) and the influenza A (H1N1) pandemic provide evidence of the benefits of the new global monitoring and of the importance of the World Health Organization in its coordinating role in the multilateral response of the global public health community.

disease outbreaks; internationality; population surveillance; review; world health

Abbreviations: AIDS, acquired immunodeficiency syndrome; CDC, Centers for Disease Control and Prevention; GIS, geographic information system; HIV, human immunodeficiency virus; IHR, International Health Regulations; ISRP, international surveillance and response program; NBIC, National Biosurveillance Integration Center.

INTRODUCTION

With the transition from the 20th century into the 21st century, international travel, trade, and commerce as core dimensions of globalization have become key forces in reshaping public health at the national and international levels. Globalization and global health are terms being used persistently during the new millennium, as illustrated by an enormous cadre of new publications, such as the World Health Organization’s Global Burden of Disease (1, 2), the Institute of Medicine’s reports on global health (3, 4), and the explosion of multiple new global health entities, such as global health initiatives and funds (5–7), global health commissions (8, 9), global health alliances such as the Global Health Council (10), creation of new global health departments in more academic institutions, launching of new global health journals (11–13), anthologies in global health (14–16), and even the creation of global health television (17).

There is consensus among the public health community that one of the most relevant essential functions in global health is global health surveillance. In the last few years, global epidemiologic surveillance has been the subject of a major revision and overhaul. Global surveillance has been reshaped by important changes in the new International Health Regulations (18, 19) and the rapid development of new global public health networks for disease surveillance and bioterrorism (20, 21). These networks provide for the first time at the global scale real-time information about potential outbreaks and epidemics of newly emerging and reemerging infectious diseases. In addition, critical information for selected diseases and public health risks is now systematically collected and uploaded to the Internet for documenting the escalating environmental pressures, monitoring current human immunodeficiency virus (HIV)/acquired immunodeficiency syndrome (AIDS) and influenza pandemics, identifying “hot spots” for natural and human-made disasters, and recognizing potential...
bioterrorist threats around the world. Most of this information is now available for the consultation of the professional community but also has been made accessible to the general public through public and private websites.

The aim of this review is to provide an update of the current state of knowledge on global surveillance and to identify how the new directions of global surveillance are transforming the functions of public health in a globalized world. Three key areas will be highlighted in this review: 1) the role of the new International Health Regulations, 2) the emergence of new global health networks for surveillance and bioterrorism, and 3) the reshaping of guidelines and mechanisms for the collection, dissemination, and interventions in global surveillance. A discussion is also presented of the more important challenges and directions of global health surveillance.

Although a large percentage of national surveillance reports and documents are published as "gray literature" as they serve internal institutional staff, with the assistance of the Internet and the expansion of Web-based technologies, we observe an explosion in the availability of articles, publications, and information using the terms "global surveillance," "global epidemiological surveillance" and "global health surveillance." Google searches identify almost 15 million entries for the term "global health surveillance." By use of the same National Library of Medicine Medical Subject Headings (MeSH) term, a search in PubMed (also from the National Library of Medicine; http://www.ncbi.nlm.nih.gov/entrez/query/static/citmatch.html) provided 9,049 recent scientific publications with this term. Examining the recent literature on global health surveillance was an important step in identifying the major transformations occurring in health and security surveillance, including the role played by military agencies, academic institutions, and the new participation of the private sector. For the purpose of this article, the Web-searched articles and publications were reviewed and classified in the 3 main categories related to this review: global surveillance legal framework, global surveillance networks, and applications and guidelines related to the main types of surveillance. In addition to the PubMed search, the review was complemented by direct interviews with officials responsible for the main regional and global surveillance systems. Also, there was a review of key documents on global health surveillance on the websites of the World Health Organization, Pan American Health Organization, Centers for Disease Control and Prevention (CDC) in the United States, Canada, and Europe, Institute of Medicine, US National Institutes of Health, US Government Accountability Office, US Department of Homeland Security, US Department of Health and Human Services, US Agency for International Development–Health Section, and several ministries of health.

RESHAPING THE INTERNATIONAL HEALTH REGULATIONS FOR GLOBAL HEALTH SURVEILLANCE

Globalization of trade and the economy has resulted in a constant massive mobilization of commodities and people across countries and continents at unprecedented speed. It takes only a few hours to transport or mobilize thousands of people and goods across the globe. It is recognized that it is possible to travel between most places in the world in less time than the incubation period for many infectious diseases (22). At the same time, in the health sector, there have been important debates about the role of health in human development. The collective works of the United Nations’ Global Commission on Macroeconomics and Health (8), the Global Commission on Social Determinants of Health (9), and the United Nations’ Millennium Development Goals Report of 2009 (23) have been instrumental in recognizing the global importance of health as an essential component of human development and of the critical global need for essential public health goods (24, 25). International Health Regulations are considered an important essential public health good.

Since the latter part of the 19th century, the dissemination of global surveillance information generally has been done by "weekly reports" of diseases of critical health or strategic importance.

In the United States, the Weekly Abstract of Sanitary Reports, published since 1886 in Washington, DC, at the Marine Hospital Bureau in accordance with an act of Congress of April 29, 1878, has included morbidity and mortality information for most cities and ports of the United States and many countries of the world (26). In 1907, most of the European states that had negotiated the 19th century international sanitary conventions met in Rome and adopted an agreement establishing L’Office International d’Hygiène Publique (often referred to as “OIHP” or International Bureau of Public Health) with a permanent secretariat in Paris (27). The first issue of the Weekly Reports was published in April 1926 by the Health Section of the Secretariat of the League of Nations in Geneva, Switzerland (28). This weekly health record included information regarding the prevalence and mortality of 5 important diseases: plague, cholera, yellow fever, typhus, and smallpox. The information feeding this report was transmitted by telegrams.

In 1902, an international conference of American states meeting in Washington, DC, established the International Sanitary Bureau, the predecessor of the Pan American Sanitary Bureau and the present Pan American Health Organization. The 1892 and 1897 conventions were replaced in 1903 by a new International Sanitary Convention. In the Americas, the first issue of the Pan American Sanitary Bulletin was published in 1922 (29). Initially, this publication presented a global summary of infectious disease notification. The “weekly sanitary reports” were created in 1929 as part of the effort for disseminating the reporting of diseases under global surveillance.

A recent World Health Organization publication documents, “Between the wars (1918–1939), international health regimes were not well coordinated. Between 1919 and 1945, the health office of the League of Nations in Geneva, the Pan-American Sanitary Bureau in Washington, DC, and the International Bureau of Public Health in Paris, existed independently of each other and enforced conventions and agreements within their respective areas” (19, p. 2).
After the creation of the World Health Organization in 1945, the role of reporting on infectious diseases globally was assumed by this new organization through the Weekly Epidemiological Record (30), incorporating the Weekly Record of the Health Section of the Secretariat of the League of Nations. The International Health Regulations, originally designated the “International Sanitary Regulations,” were issued in 1951 by the World Health Organization, and there have been few significant changes for most of the second part of the 20th century. The International Sanitary Regulations were renamed in 1969 as the “International Health Regulations” (IHR). Minor adjustments were made in 1979, and the global monitoring of AIDS was added in 1981. The IHR have been the only regulatory source for the global surveillance of priority infectious diseases. However, in the initial years of the 21st century, a new major overhaul was proposed for these Regulations citing the urgent need for increasing global health security and for the coordination of the global public health response to natural disasters, accidental release, or deliberate use of biological and chemical agents or radionuclear material that can affect global public health. In addition, the world experienced major challenges by the AIDS epidemic, the severe acute respiratory syndrome (SARS) epidemic, and the emergence of dozens of new diseases and pathogens. The newly revised International Health Regulations-2005 (IHR-2005) were approved by all 194 World Health Organization member states. These health regulations entered into force in 2007 (31).

Surveillance was defined by the IHR-2005 as the “...systematic ongoing collection, collation and analysis of data for public health purposes and the timely dissemination of public health information for assessment and public health response as necessary” (32, p. 10). This definition expanded the traditional focus from monitoring 3 specific diseases (cholera, yellow fever, and plague) to expanding the efforts to prevent and control the international spread of diseases with high risk of a global pandemic and any major public health risks, including biologic and chemical agents or nuclear radiation that affect global health under a multilateral public health response. The IHR-2005 extended the types of events to be reported internationally. It introduced new key terms, such as “public health risk” and “public health emergency of international concern,” as events under which the Regulations apply. A global health emergency was defined as an “extraordinary event” that is determined by the following: 1) It constitutes a public health risk to other states through the international spread of disease; and 2) it potentially requires a coordinated international response. In this regard, countries are required to notify the World Health Organization of all events that may constitute a “public health emergency of international concern” according to the agreed framework of the Regulations. One of the key goals of the IHR is to monitor the emergence of any “public health emergency of international concern” (31, p. 5).

Moreover, under the INR-2005, every country is required to designate a national IHR center that shall be accessible at all times for communications with the World Health Organization IHR coordinators.

During the revision of the IHR, there were important debates on the future direction of global surveillance, particularly in light of the 3 key global factors: 1) the constant emergence of new diseases and pathogens and the re-emergence of conditions that were under public health control; 2) the terrorist attacks of September 11, 2001, in New York City and the threats of bioterrorism in other cities around the globe; and 3) the unprecedented expansion of the Internet and information technology.

According to different scientists, agencies, and organizations (33–44), during the last decades, 20 well-known diseases—including tuberculosis, malaria, and cholera—have reemerged and spread globally, often in more virulent and drug-resistant forms. In addition, it has been reported that at least 30 previously unknown disease agents have been identified, including HIV, Ebola hemorrhagic fever, hepatitis C, Lyme disease, Nipah virus, West Nile virus, severe acute respiratory syndrome, avian flu virus, and influenza A (H1N1) virus, for which no adequate treatments are available.

Jones et al. (45) published an extensive and enlightening analysis of the emergence and trends of 335 new infectious diseases, called “emerging infectious disease events.” They reported that most of these were zoonoses (60.3%), that the majority (71.8%) originated in wildlife, and that they were increasing significantly over time. They also indicated that the peak incidence of these emerging infectious disease events occurred in the 1980s concomitant with the HIV pandemic. The results of this study suggested that the origins of emerging infectious disease events are significantly correlated with socioeconomic, environmental, and ecologic factors, providing a basis for identifying regions where new emerging infectious disease events are most likely to originate.

As more than 60% of the new emerging diseases causing devastating outbreaks have their source in interactions between animals and humans, an innovative way to identify a predictive landscape of emerging communicable diseases is to use data related to human and animal interactions and environmental and spatial sociodemographic data. Mapping “hot spots” for emerging diseases has proved to be a useful insight of the distribution of the factors that affect the emergence of zoonotic diseases. In 2009, the US Agency for International Development (46, 47) launched its multi-million dollar “Emerging Pandemic Threats” program as a major global initiative to preempt or combat, at their source, newly emerging diseases of animal origin that might threaten human health. This program includes 5 interconnected projects. The 5 projects are described as follows: 1) PREDICT (a 5-year agreement of leading global experts in wildlife surveillance to monitor for and increase the local capacity in mapping geographic hot spots to identify the emergence of new communicable diseases in high-risk wildlife); 2) RESPOND (a 5-year agreement of private and academic institutions with the objective of training in outbreak investigation and response linking animal and human disease detection and control); 3) IDENTIFY (an agreement with the World Health Organization, Food and Agriculture Organization, and the World Organization for Animal Health supporting the development of laboratory networks and strengthening diagnostic capacities for new emerging zoonotic diseases); 4) PREVENT (a 5-year agreement with an
education agency and private sector to develop better communication strategies and behavior change responses to modify “high-risk practices” that affect the potential of new disease threats from wildlife); and 5) PREPARE (a 5-year agreement awarded to a humanitarian, nonprofit organization to provide technical cooperation and support for national, regional, and local pandemic preparation to help countries in improving their capacity to respond to pandemic events).

This new overreaching program illustrates the relevant role that is placed on monitoring and surveillance of wildlife at the global scale. More communication and coordination among veterinary and human epidemiologists are needed for the success of these new global surveillance initiatives.

The current, observed trends of communicable diseases and chronic illness, natural disasters, violence, and bioterrorism present an unprecedented challenge for global health, particularly as they are occurring at the time of one of the most difficult economic global crises in recent history. As a consequence of globalization, the world today is more interconnected by means of transportation and faster communication, and this has resulted in new patterns of travel and migration. Borders have become open, not only for the circulation of newly emerging and reemerging infectious disease pathogens but also for copying healthy and unhealthy communities’ behaviors and individuals’ lifestyles. Global health surveillance is an important mechanism for detecting changes in the epidemiologic patterns of both emerging and reemerging diseases and allows for the detection of outbreaks, hot spots of diseases, or any public health risks, including those introduced by bioterrorism.

GLOBAL BIOTERRORISM SURVEILLANCE

Global health is seen in several developed countries as a pillar of their foreign policy, and several governments are expanding their investment in global health and global security (48–52). The area of global security has been rapidly expanded in the last 10 years, and both national governments and multilateral organizations are involved in investing and deploying new surveillance systems that target the early manifestations of bioterrorism-related diseases.

The 2001 terrorist attacks in New York and the concomitant situations in other cities around the world where highly pathogenic microbes such as anthrax and plague have been used as weapons against the public have changed the way most governments and people see national and global health security. Now, the term bioterrorism is constantly present in media and news reports. It becomes an additional major concern for the protection and security of the population in most countries. This increase in awareness by civil and military agencies in most countries of the world has emphasized the importance of more public health and better global public surveillance.

The World Health Organization responded to the global security situation of recent years by presenting its initiative in “Global Health Security: Epidemic Alert and Response” (53–55). Also, a critical part in the debates for the reformulation of the IHR-2005 was the call for the incorporation by public health agencies of terrorism preparedness and health security. The IHR-2005 was seen as a major step forward for managing biorisks that will enhance global health and security significantly.

As part of this global awareness, several national public health agencies have prepared a series of reports and protocols to assist in emergency preparedness and response to bioterrorism. In the United States, the CDC, US Agency for International Development, Department of Defense, Department of Homeland Security, the Institute of Medicine, the National Institutes of Health, and the Department of Health and Human Services have been developing an extensive collection of materials to assist in better security preparedness and response to bioterrorism threats. Among the materials prepared are protocols with detailed information including bioterrorism case definitions for key agents, such as anthrax, botulism, brucellosis, plague, smallpox, and tularemia (56, 57).

In a recent report, the CDC provides guidance for public health professionals about recognizing illness patterns that might be associated with intentional use of biologic agents. In this report, the CDC recognizes that there are “three categories of biologic agents with potential to be used as weapons, based on ease of dissemination or transmission, potential for major public health impact (e.g., high mortality), potential for public panic and social disruption, and requirements for public health preparedness. Agents of highest concern are Bacillus anthracis (anthrax), Yersinia pestis (plague), variola major (smallpox), Clostridium botulinum toxin (botulism), Francisella tularensis (tularemia), filoviruses (Ebola hemorrhagic fever, Marburg hemorrhagic fever); and arenaviruses (Lassa [Lassa fever], Junin [Argentine hemorrhagic fever], and related viruses)” (58, p. 894).

Buehler et al. (59) provided an illustrative assessment of the potential effectiveness of 2 types of surveillance (clinical recognition vs. syndromic surveillance) to recognize the main signs and characteristics of bioterrorism-related epidemics. They concluded that the potential success of these surveillance systems depends on recognizing 4 characteristics: incubation period of the agent, duration of the prodromal phase, presence of clinical signs, and the probability of making a diagnosis during the routine evaluation. This study also provides useful information and key references for syndromic surveillance and bioterrorism.

The US Department of Homeland Security in response to Homeland Security Presidential Directive 9 established in 2004 a national policy to protect the agriculture and food infrastructure against terrorist attacks, major disasters, and important emergencies. This policy emphasized the development of new early warning surveillance systems to recognize threats against the food infrastructure (60).

When effectively applied to communicable diseases, surveillance provides essential information for action against infectious disease risks and threats. The surveillance community recognizes that basic surveillance involves 4 functions: 1) detecting cases of disease in specific populations and reporting the information, 2) analyzing and confirming reported case information to detect outbreaks, 3) providing timely and appropriate responses at the national and international level to prevent and control disease outbreaks, and 4) providing epidemiologic intelligence information to assist in long-term management of public health and health-care policies and
programs. Epidemic alerts and effective responses are needed to ensure adequate global public health.

First recognized as a global threat in mid-March 2003, severe acute respiratory syndrome was successfully contained in less than 4 months. This important landmark in global surveillance and response was possible because of the intensive collaborative work of thousands of scientists and hundreds of institutions, when in the past it would have taken several years to accomplish the same (e.g., the global AIDS epidemic). On July 5, 2003, the World Health Organization reported that the last human chain of transmission of severe acute respiratory syndrome had been broken (61).

THE RAPID EXPANSION OF HEALTH INFORMATION TECHNOLOGIES AND THE INTERNET

A changing world and the occurrence of new emerging diseases and pathogens have produced a great need of not only good laboratory and surveillance capacity but also efficient ways and channels of international communication. With the Internet explosion and expanding virtual communications, surveillance information for the first time could be accessible in real time to any place in the world for those with virtual connectivity. Virtual communication has transformed the way information is shared and used. It had a dramatic impact on the new developments in global health surveillance, including the e-Health networks for disease surveillance and dissemination of information and alerts in real-time.

There is great interest over the use of promising interactive health information technologies—often referred to as eHealth—and the potential that these technologies have to improve the quality, capacity, and effectiveness of the global surveillance systems.

Ginsberg et al. (62) presented a novel approach for detecting influenza outbreaks using search engine query data. They analyzed historical logs of more than 50 million of the most common online Web search queries in the United States to track influenza-like illness in different areas and regions of the country. They reported that they were able to recognize a high correlation of Google queries (influenza-like illness-related search queries) with the percentage of physician visits in patients with influenza-like symptoms. The benefits discussed in this report are related to the timeliness and broad-reaching of this influenza monitoring, allowing public health professionals to organize a more effective early response. The potential limitations described are related to the possibility of false alerts due to unusual events, such as drug recall for a cold remedy or by the presence of panic in the population.

These new health information technologies and the Internet are important drivers affecting the future directions of global surveillance communications, particularly facilitating the collection and transmission of information at speeds that allow for better emergency preparedness and response. In addition, the virtual information is immediately accessible to different public health stakeholders and the general public over the world.

New terms linking surveillance and public health informatics are being proposed to analyze patterns of search and communication of surveillance information on the Internet. Eysenbach (63) has described the fields of “infodemiology and infoveillance” as methods to be used for the analysis of queries from the Internet search engines to predict disease outbreaks. In addition, these informatics methods are proposed to be used to analyze search behaviors of people and navigation patterns in the Internet for health-related information, including how people communicate and share health and surveillance information.

NEW GLOBAL HEALTH NETWORKS FOR HEALTH SURVEILLANCE

As mentioned in the Introduction, the term “global health” has gained greater importance. The concept of “international health” traditionally linked to national governments and international agencies has evolved to include the concept of global health incorporating other important stakeholders and multinational players including the private sector, new global private foundations, and civil society groups. This transition has encouraged the discussion of global public health goods (64–66).

An unprecedented proliferation of global and regional surveillance networks occurred in the last decade as a response to the challenges of global public health.

A recent analysis by Wilson and Brownstein (67) provides helpful examples of how Internet surveillance tools can assist in the early identification of disease outbreaks. The article concludes that Web-based sources of information in addition to allowing timely detection of outbreaks will reduce cost and increase reporting transparency. These authors presented a useful list of major advantages and disadvantages of “Internet-based surveillance.”

Hitchcock et al. (68) prepared a landmark review of 15 international surveillance and response programs (ISRPs). This review offers a useful classification of these key global systems. The classification is organized by the 4 basic components of surveillance and response programs: surveillance, reporting, verification, and response. These authors concluded that only 6 ISRPs cover the 4 components of surveillance and response, 5 ISRPs include the surveillance and reporting components, and 3 ISRPs have verification and response components. The 6 ISRPs are as follows: the Global Polio Eradication Initiative, the Regional Immunization Program of the Americas, the Global Disease Detection (GDD) Program, the Biological Threat Reduction Program, and the Epidemic and Pandemic Alert and Response. The 5 ISRPs are the following: Global Public Health Intelligence Network, ProMED-mail, QFLU (a not-for-profit network of over 3,300 general practices spread throughout the United Kingdom covering a total population of almost 22 million patients), European Influenza Surveillance Scheme, and the Global Influenza Surveillance Network. The 3 ISRPs are as follows: Outbreak Alert and Verification System, Global Outbreak Alert and Response Network, and the Preparedness and Response Unit.

A description of the leading surveillance systems and platforms is included in Table 1.

In 1997, a very original global surveillance initiative was proposed by the World Health Organization in partnership...
with the Canadian Agency of Public Health to help identify significant disease outbreaks around the world taking advantage of the existing globalized virtual communications. The Global Public Health Intelligence Network (69) is an Internet surveillance system that gathers data and public health reports from diverse countries in 7 languages, aiming to disseminate timely alerts to help control outbreaks, the spread of infectious disease, contamination of food and water, bioterrorism, natural disasters, and exposure to chemical agents and nuclear materials. This system also monitors questions related to the safety of medications and medical products (70). The system assists the World Health

### Table 1. Selected Leading Surveillance Systems and Platforms

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
<th>Website Address</th>
<th>Description and Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPHIN</td>
<td>Public Health Agency, Government of Canada</td>
<td><a href="http://www.cdc.gov/globalhealth/GDD/gddoperation.htm">http://www.cdc.gov/globalhealth/GDD/gddoperation.htm</a></td>
<td>Leading global Web-based network providing surveillance information to WHO/GOARN and subscriber agencies (for a fee). This network monitors Internet media, such as news wires and websites, in 7 languages to help detect and report potential disease outbreaks around the world. This system is one of the first global monitoring systems using real-time data.</td>
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<tr>
<td>GOARN</td>
<td>WHO</td>
<td><a href="http://www.who.int/csr/outbreaknetwork/en/">http://www.who.int/csr/outbreaknetwork/en/</a></td>
<td>Defined by the WHO as the global network of surveillance networks. Receives surveillance information from the GPHIN and official country sources. This is the main surveillance network of the WHO with the collaboration of more than 140 institutions. GOARN’s mission is the rapid identification and/or confirmation and effective response to disease outbreaks of international public health importance.</td>
</tr>
<tr>
<td>ProMED-mail</td>
<td>Initial SatelLife (Boston, Massachusetts) and since 1999 the International Society for Infectious Diseases</td>
<td><a href="http://www.promedmail.org/pls/apex/f?p%C2%BC2400:1000">http://www.promedmail.org/pls/apex/f?p¼2400:1000</a></td>
<td>Nonprofit, free e-mail list network serving over 40,000 subscribers in more than 150 countries. Global electronic reporting system since 1993. One of the leading e-mail surveillance-reporting systems.</td>
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<tr>
<td>HealthMap</td>
<td>Open-accessed GIS network supported by Google.org</td>
<td><a href="http://healthmap.org/en">http://healthmap.org/en</a></td>
<td>Free Internet GIS network collecting, organizing, and displaying infectious disease outbreaks. This website integrates outbreak data of varying reliability, ranging from news sources (such as Google News) to curated personal accounts (such as ProMED) to validated official alerts (such as the WHO). This is a leading tracking system and one of the most-used surveillance networks using GIS technology.</td>
</tr>
<tr>
<td>FERN</td>
<td>US Department of Homeland Security</td>
<td><a href="http://www.fernlab.org/">http://www.fernlab.org/</a>; <a href="http://www.fernlab.org/fernregions/structure.cfm">http://www.fernlab.org/fernregions/structure.cfm</a></td>
<td>This system integrates the US food-testing laboratories at the local, state, and federal levels into a network that is able to respond to emergencies involving biologic, chemical, or radiologic contamination of food.</td>
</tr>
<tr>
<td>ESSENCE</td>
<td>US DoD</td>
<td><a href="http://www.ncbi.nlm.nih.gov/pubmed/12791777">http://www.ncbi.nlm.nih.gov/pubmed/12791777</a></td>
<td>Tracking system of syndromic and nontraditional health information reported daily from regional hospitals and clinics in the Washington, DC, area. ESSENCE II was developed for the Department of Defense Global Emerging Infections System and is the only known system to combine both military and civilian health-care information for daily outbreak surveillance.</td>
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Table continues
Organization as an outbreak verification process. Between November 1999 and October 2000, the World Health Organization investigated 228 outbreak reports with 169 confirmed as outbreaks of global health significance (71). The most recent one is the declared pandemic level VI of influenza H1N1 (72).

The Global Public Health Intelligence Network currently has more than 100 laboratories and disease notification

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**Table 1. Continued**

<table>
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<tr>
<th>Name</th>
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<th>Description and Activities</th>
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<tr>
<td>RODS Laboratory</td>
<td>University of Pittsburgh</td>
<td><a href="http://rods.health.pitt.edu/Fact%20Sheets/RODS%20Implementation%20Info.pdf">http://rods.health.pitt.edu/Fact%20Sheets/RODS%20Implementation%20Info.pdf</a>; <a href="https://www.rods.pitt.edu/site/">https://www.rods.pitt.edu/site/</a></td>
<td>Syndromic surveillance system using data on symptoms (nonspecific indicators for disease outbreaks) of emergency room patients.</td>
</tr>
<tr>
<td>NRDM</td>
<td>RODS Laboratory, University of Pittsburgh</td>
<td><a href="http://rods.health.pitt.edu/NRDM.htm">http://rods.health.pitt.edu/NRDM.htm</a>; <a href="http://www.cdc.gov/MMWR/preview/mmwrhtml/su5301a9.htm">http://www.cdc.gov/MMWR/preview/mmwrhtml/su5301a9.htm</a></td>
<td>Review of daily sales of selected over-the-counter health-care medications and products from more than 15,000 retail stores. Trends and data are available to public health professionals (117).</td>
</tr>
<tr>
<td>Project Argus</td>
<td>Medical Center, Georgetown University, Washington, DC</td>
<td><a href="http://www.cdc.gov/globalhealth/GDD/gddoperation.htm">http://www.cdc.gov/globalhealth/GDD/gddoperation.htm</a>; <a href="http://www.cdc.gov/washington/EGlobalHealthEditions/E-brief_first_quarter_2008.pdf">http://www.cdc.gov/washington/EGlobalHealthEditions/E-brief_first_quarter_2008.pdf</a></td>
<td>Biosurveillance system detecting and tracking early signs of international biologic events. The 3 types of events are as follows: reports of disease outbreaks, potential environmental triggers, and social disruption. It provides alerts to CDC and other key users about events that require public health intervention.</td>
</tr>
<tr>
<td>Veratect Corporation</td>
<td>Private sector: biosurveillance private firm (Kirkland, WA)</td>
<td><a href="http://www.veratect.com/">http://www.veratect.com/</a></td>
<td>Leading private biosurveillance platform serving as an early warning system. It collects information from open-source reports and a global network of contacts. Tracks and locates global disease outbreaks and warns governments of any disease pattern compatible with an initial pandemic.</td>
</tr>
<tr>
<td>MedSys</td>
<td>European Commission</td>
<td><a href="http://ec.europa.eu/health/ph_threats/com/preparedness/medical_intelligence_en.htm">http://ec.europa.eu/health/ph_threats/com/preparedness/medical_intelligence_en.htm</a></td>
<td>Surveillance system available only to European Union member countries. The system includes an information scanning tool to support the surveillance of communicable diseases and early detection of bioterrorism activities in Europe.</td>
</tr>
<tr>
<td>GAINS</td>
<td>Wildlife Conservation Society with the support of USDA, USAID, FAO, and other agencies</td>
<td><a href="http://www.gains.org">http://www.gains.org</a></td>
<td>Global initiative providing surveillance for influenza in wild birds. Collaborators in the GAINS network collect and analyze biologic samples from wild birds (which are caught and released), to identify locations of the avian influenza viral strain. The program disseminates information on avian influenza to governments, international agencies, and the public.</td>
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</tbody>
</table>

Abbreviations: BIWAC, Biosurveillance Indications and Warning Analytic Community; CDC, Centers for Disease Control and Prevention; DHS, Department of Homeland Security; DoD, Department of Defense; ESSENCE, Electronic Surveillance System for the Early Notification of Community-based Epidemics; EUROFLU, European Region surveillance network for influenza; FAO, United Nations Food and Agriculture Organization; FERN, Food Emergency Response Network; GAINS, Global Avian Influenza Network for Surveillance; GIS, geographic information system; GOARN, Global Outbreak Alert and Response Network; GPHIN, Global Public Health Intelligence Network; HealthMap, Global Disease Alert Map; ICLN, Integrated Consortium of Laboratory Networks; MEDSYS, European Commission's Medical Intelligence System; NBIS, National Biosurveillance Integration System; NRDM, National Retail Data Monitoring (the RODS Laboratory is the home of NRDM); Project Argus, the name “Argus” derives from a 100-eyed being in Greek mythology; ProMED, Program for Monitoring Emerging Diseases; RODS, Real-Time Outbreak and Disease Surveillance System; USAID, US Agency for International Development; USDA, US Department of Agriculture; WHO, World Health Organization.
systems that provide immediate reports utilizing high technology, such as systematic scanning of electronic resources including websites, news, electronic public health services, and Internet discussion groups. Global Public Health Intelligence Network members can be governmental and non-governmental agencies that promote norm setting through wider use of this information.

Table 2 shows a list and links of selected Internet sites developed by the World Health Organization for the monitoring and surveillance of global health events.

The World Health Organization has created a global network of 111 national influenza centers in 83 countries, supported by 4 collaborative reference laboratories located in the United States (CDC), United Kingdom, Japan, and

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**Table 2. List of Selected Internet Sites Developed by the World Health Organization for Monitoring and Surveillance of Global Health Events**

<table>
<thead>
<tr>
<th>WHO’s Global Health Surveillance Sites</th>
<th>Description and Type of Indicators Under Global Surveillance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic health operations</td>
<td>The WHO established this “central health situation room” in 2004. SHOC has been defined as “the nerve centre of WHO’s global epidemic response providing a single point of coordination for response to acute public health crises including infectious disease outbreaks, natural disasters, and other emergencies. It is the hub of alert and response operations, combining the latest in information and communications technologies to support field operations and facilitate collaboration with Member States and technical partners in external networks such as the GOARN” (<a href="http://www.who.int/csr/alertresponse/shoc/en/">http://www.who.int/csr/alertresponse/shoc/en/</a>).</td>
</tr>
<tr>
<td>Global Outbreak Alert and</td>
<td>GOARN’s mission is the rapid and/or confirmation and effective response to disease outbreaks of international public health importance. Receives surveillance information from the Global Public Health Intelligence Network and the official country sources. This is the main surveillance network of the WHO with the collaboration of more than 140 institutions.</td>
</tr>
<tr>
<td>Response Network</td>
<td></td>
</tr>
<tr>
<td>FluNet</td>
<td>FluNet is the Web-based data collection and reporting tool of the GISN. FluNet includes virologic influenza information since 1995 from countries worldwide, provided by national influenza centers and other national influenza reference laboratories collaborating actively with the GISN. Data entry is restricted, and data entry access is password protected. Data reports including tables, maps, and graphs are available to all public users.</td>
</tr>
<tr>
<td>DengueNet</td>
<td>DengueNet is part of the Global Health Atlas platform and functions as the WHO’s central data management system for the global epidemiologic and virologic surveillance of dengue fever and dengue hemorrhagic fever. The network collects standardized data from all DengueNet partners worldwide and provides Web access to key indicators, such as incidence, case fatality rates, frequency and distribution of dengue fever and dengue hemorrhagic fever cases, number of fatalities, and circulating virus serotypes.</td>
</tr>
<tr>
<td>RabNet</td>
<td>“Rabnet version2” is a Web-based data collection tool and interactive information system for the generation of graphs and maps with human and animal rabies data. The system produces yearly updates at the country level and the first administrative level (province or state).</td>
</tr>
<tr>
<td>Global Health Atlas</td>
<td>This WHO system aims to provide a single point of access to data, reports, and documents on the major diseases of poverty including malaria, HIV/AIDS, tuberculosis, diseases in the process of eradication and elimination (such as guinea worm, leprosy, lymphatic filariasis), and epidemic-prone and emerging infections (i.e., meningitis, cholera, yellow fever, and antiviral drug resistance). The systems have 3 capabilities: data query; interactive mapping; and maps and resources.</td>
</tr>
<tr>
<td>Global Malaria Programme</td>
<td>The malaria surveillance database is part of the WHO’s Communicable Disease Global Atlas, and it includes information on reported cases of malaria and other key malarial indicators.</td>
</tr>
<tr>
<td>Global Tuberculosis Database</td>
<td>This database has tabulated data and maps by country and region of 5 main TB indicators: DOTS population coverage, estimated TB cases, reported TB cases, case detection rate (MDG indicator 24), and treatment success (MDG indicator 24). This database also includes estimates of TB mortality.</td>
</tr>
<tr>
<td>Global Alliance for the elimination</td>
<td>This site produces tabulations for the main surveillance indicators related to the elimination of blinding trachoma: active trachoma (trachomatous inflammation—follicular/intense), all ages (2003); cicatricial trachoma (trachomatous trichiasis), all ages (2003); people to operate in endemic areas (UIG-S) (2003); people to treat in endemic areas (UIG-A) (2003); population living in endemic areas (2003); and prevalence (%), ages, trachomatous inflammation—follicular/intense (2003). Currently, only 2003 data are available on the site.</td>
</tr>
<tr>
<td>of Blinding Trachoma</td>
<td></td>
</tr>
<tr>
<td>Project Atlas for mental health and</td>
<td>Project Atlas was designed to collect, compile, and disseminate data on mental health and neurology resources in the world. Resources include policies, programs, financing, services, professionals, treatment and medicines, information systems, and related organizations. The site provides tables, charts, and maps displaying global, regional, and country data on mental health and neurology disorders.</td>
</tr>
<tr>
<td>neurologic disorders</td>
<td></td>
</tr>
<tr>
<td>Global Information System on Alcohol and Health</td>
<td>A global surveillance site for continuous monitoring of alcohol consumption, alcohol-related harm, and policy responses. This database system was developed in 1997. The indicators selected are organized in 8 domains. The system is overseen by the WHO and collaborative centers in Canada and Switzerland.</td>
</tr>
<tr>
<td>Global Atlas of the Health Workforce</td>
<td>This site includes 2 sets of data: a main (aggregated) set and a disaggregated set. The aggregated data set includes estimates of the absolute numbers and rates per 1,000 population of health workers for 9 occupational categories. This includes 1) physicians, 2) nursing and midwifery personnel, 3) dentistry personnel, 4) pharmaceutical personnel, 5) laboratory health workers, 6) environmental and public health workers, 7) community and traditional health workers, 8) other health service providers, and 9) health management and support workers.</td>
</tr>
</tbody>
</table>

Abbreviations: AIDS, acquired immunodeficiency syndrome; DOTS, directly observed treatment, short course (the internationally recommended strategy to control tuberculosis); GISN, Global Influenza Surveillance Network; GOARN, Global Outbreak Alert and Response Network; HIV, human immunodeficiency virus; MDG, Millennium Development Goals; SHOC, Centre for Strategic Health Operations; TB, tuberculosis; UNG-A, ultimate intervention goals for antibiotics; UNG-S, ultimate intervention goals for [trichiasis] surgery; WHO, World Health Organization.

* Source: WHO website (http://www.who.int/en/).
Australia (71, p. 12). These international reference laboratories collaborate in collecting and analyzing influenza strains to identify those that are most likely to become a major risk to global health. The World Health Organization also created “FluNet” (73) and “DengueNet” (20) as Internet sites dedicated to monitoring global influenza activity and gathering and sharing dengue-related information, respectively.

A very dynamic network of Internet-based surveillance was initiated by the International Society of Infectious Diseases’ Program for Monitoring Emerging Diseases. ProMED-mail at present is considered to be one of the largest publicly available Internet-based reporting networks in the world (74, 75).

Access to the enabling geographic information system (GIS) technology has facilitated the deployment of informatics protocols aimed at automated classification and visualization of Internet media reports on disease outbreaks. HealthMap is a new global disease alert map website launched in September 2006 by the HealthMap Organization (76) with the sponsorship of Google Earth. Currently, this open source platform is available in 7 languages, and it integrates outbreak data from news sources (such as Google News), curated personal accounts (such as ProMED), and validated official alerts (such as the World Health Organization). Through an automated text-processing system, the data are aggregated by disease and displayed as thematic maps by location for user-friendly access to the original alert. The HealthMap site indicates that it provides real-time information on emerging infectious diseases that may have particular interest for public health officials and international travelers by integrating and filtering news from over 20,000 sources every hour.

The US Department of Defense has created a global infectious disease surveillance network known as the Emerging Infectious Surveillance and Response System or “DoD-GEISWeb.” This global surveillance system focuses on surveillance for drug-resistant malaria, antibiotic-resistant enteric organisms, influenza, and unexplained febrile illness. Through the use of its overseas laboratories, this network collaborates with institutions in 38 countries (77).

In 2003, in collaboration with the Virginia Bioinformatics Institute, the US Department of Defense sponsored the deployment of an Internet portal named “Pathogen portal project” (PathPort) and dedicated to the important global pathogens. This Internet site was designed to provide information from different areas of the world about high-risk pathogens with the potential to be used as biological weapons. PathPort incorporated bioinformatics tools and GIS technology to assist in the rapid detection, identification, visualization, and forensic attribution of high-priority pathogens (78). However, in August 2008, many of the functionalities of this site were eliminated because of financial constraints.

Several important surveillance collaborative efforts have been launched in the United States in the attempt to better coordinate the different surveillance systems for monitoring bioterrorist threats and public health emergencies. A 2007 report from the Department of Homeland Security has documented that, since the anthrax threats of 2001 and the 9/11 events, the United States has spent nearly $32 billion on biodefense and biosurveillance with uneven results (79).

As part of the major endeavor of developing and expanding biosurveillance systems, the US Department of Homeland Security established in late 2008 its National Biosurveillance Integration Center (NBIC) in response to the potential threats of bioterrorism and epidemics that may affect US national security (80). The NBIC was presented as an effort to coordinate and consolidate diverse existing information systems detecting biological events of public health importance. The NBIC’s main objective was to integrate data generated from local, state, and federal agencies and the private sector into a coherent national biosurveillance system; 12 federal agencies have agreed to exchange information on the NBIC platform. The NBIC has been described as a “one-stop shop for human, animal, and plant biosurveillance information” (81, p. 3). In addition to the NBIC, the Department of Homeland Security created the “BioWatch Program” for its activities in research and development on “next generation bio-detectors” or sensors to be used in an environmental monitoring system for early detection of airborne biological threat agents in more than 30 cities in the United States. As part of this biosurveillance collaborative initiative, several coordination protocols, mechanisms, and operational frameworks were developed for the exchange and validation of health-related information. Among these efforts are the Integrated Consortium of Laboratory Networks, the Biosurveillance Indications and Warning Analytic Community, and the Biosurveillance for Human Health Work Groups (82). These systems and working groups were developed with the objective of providing an interagency forum for collaborative exchange of information and warning mechanisms of biological events that could threaten national security and public health. Also, they are important mechanisms to promote harmonization and coordination across laboratory networks affiliated with US federal agencies.

This integration process for bioterrorism surveillance has had several problems and challenges in the coordination effort to integrate data from different agencies. A recent Government Accountability Office report has noted the major challenges in having the full participation of all sectors in making the NBIC fully operational to better predict a biological attack or biological events (83).

In addition to official government and World Health Organization sites, there are sites such as Wikipedia that produce comprehensive reports on global outbreaks. An illustrative example is the extensive report in Wikipedia of the 2009 flu pandemic by country (84). Because Web-based information sources may be present outside of the traditional reporting systems, there has been a series of informal groups informing about health events through e-mails, private websites, chat rooms, and blogs (40). This informal reporting could be valuable; however, a mechanism for verification and validation is always needed.

Several regional surveillance networks have been established recently. The European Union in 2005 established the European Center of Disease Control and Prevention. This public health agency was established as the regional surveillance site of infectious diseases in the European Union, with
the mandate to maintain the information systems and databases for the epidemiologic surveillance of 46 diseases plus severe acute respiratory syndrome, West Nile fever, and avian influenza (85).

The Pacific Public Health Surveillance Network (PPHSN) (86, 87) was created in 1996 under the joint auspices of the Secretariat of the Pacific Community and the World Health Organization. This network includes the 22 Pacific Island countries and territories of the Secretariat of the Pacific Community to improve the surveillance and response among network members of this region. Since 1998, the Pan American Health Organization provided technical assistance for the development of laboratory networks in the Amazon basin (Bolivia, Brazil, Colombia, Peru, and Venezuela) and the South Cone (Argentina, Bolivia, Brazil, Chile, Paraguay, and Uruguay). These Amazonia and Southern Cone surveillance networks use standardized case definitions for the different syndromes under surveillance. Similar subregional initiatives were promoted in Central America and the Caribbean countries. The website of the Pan American Organization provides information on the trends of priority diseases and conditions in the region and includes a portal to access all the public health surveillance systems of Latin America and the Caribbean countries (88). For West Africa, the World Health Organization has documented that the agreement of cooperation of the West African World Health Organization Epidemiologic Block was signed by 18 countries to collaborate in the control and prevention of epidemic-prone diseases (86). The Mekong Delta Project was created as a subregional surveillance network of 6 countries of the Mekong River Basin (Myanmar, Thailand, Laos, Cambodia, Viet Nam, and Yunnan province of China) for intercountry disease surveillance (89).

ROLE OF THE PRIVATE SECTOR

During the last part of the 20th century as a consequence of different economic global forces and the health sector reforms on many continents, the private sector has displayed a major expansion in the activities of the global health sector. Philanthropists and private donors have created important new global foundations with interests in participating as new actors in global health. Examples of these new foundations are the Bill & Melinda Gates Foundation, Carso Health Institute, and PepsiCo (90–92). In a short time, these foundations have revamped their efforts to becoming major drivers in global health.

There are several private companies exploring partnerships with the public sector in different areas of global health, including global health. A very dynamic new field in global health surveillance is represented by the incorporation of geographic information systems that provide new advanced analytical and technological tools for linking surveillance databases with spatial and map information (93). This field has expanded so quickly that, in 2003, the term “geographic information systems” was added to MeSH, reflecting the importance of this technology in health work (94). The Environmental Systems Research Institute (ESRI, a recognized private company located in Redlands, California) has been developing advanced GIS tools that are used in many of the current surveillance systems using real-time data. In many reviews, Google has been recognized as a major driving force for providing technologic advances in global health mapping accessible to Internet users all over the world. HealthMap, as described in a previous section, is a major open-source application for monitoring real-time global health events. Citicorp (95) has also developed a global surveillance application for simulating the response of the financial sector to major outbreaks and pandemics.

Veratec Corporation (96) is one of the leading private biosurveillance firms that collect information from open-source reports and a global network of contacts. This early warning monitoring and tracking system has been very active in informing national and local governments and international agencies of early signs of important disease outbreaks including the initial signs of the recent N1H1 influenza pandemic.

DEPLOYMENT OF HEALTH SITUATION ROOMS AND STRATEGIC COMMAND CENTERS

Health situation rooms are recognized by several ministries of health and the World Health Organization as their main strategic hubs for monitoring and surveillance activities and for coordination of their operations related to disasters and potential bioterrorist events.

Several countries and international organizations have commissioned the creation of health situation rooms, also known as “strategic command centers,” as centralized coordination hubs for national and global monitoring and the assessment of epidemic and health emergencies. Many countries have been using these centers as the epidemiologic intelligence units for coordination of the health sector with other public and private agencies required to integrate national responses to outbreaks, epidemics, and disasters. Leading examples of these centers are the Department of Health and Human Services in Washington, DC (97), and the CDC, Atlanta, Georgia (98), in the United States and the World Health Organization, Geneva, Switzerland (99), the Public Health Agency, Ottawa, Canada (100), the Ministry of Health of Brazil (101), and the Ministry of Health of Mexico (102). Currently, a large proportion of ministries of health and local health departments around the world have developed these important coordinating hubs for surveillance, alert, and response operations.

GUIDELINES AND PROTOCOLS FOR GLOBAL HEALTH SURVEILLANCE

It is recognized that all countries need to improve their disease surveillance systems to provide early detection of potential outbreaks and to establish guidelines and protocols to better respond to public health events of potential global importance. Moreover, they need to incorporate better monitoring mechanisms to enhance the safety and security of populations against terrorism and bioterrorism.

Conventional reporting in disease surveillance uses a linear “bottom-up” process (4, p. 17) initiated by a sick person.
contacting and being examined by his/her physician followed by laboratory examinations. If the results of laboratory examinations are suggestive of a “reportable” condition or recognized as being unusual in trends or numbers, the physician or laboratory notifies the local health authorities. The local health authorities inform national health authorities of the surveillance findings, and these authorities notify the World Health Organization and other international agencies, particularly if the findings are of global concern. In general, this conventional reporting process takes a long time and frequently is subject to political clearances affecting the timely alerting and the effective initiation of public health interventions. A novel process was established when surveillance systems incorporated different reporting mechanisms and sources using list servers, websites, and Internet networks.

The World Health Organization, the US Agency for International Development (USAID), the US, Canadian, and European CDCs, and other agencies provide on their websites useful practical descriptions of the different types of surveillance, including passive and active surveillance, facility-based routine surveillance, community-based surveillance, sentinel surveillance, and syndromic surveillance.

One important change in the new IHR-2005 is the obligation of governments for improving their capacity of national and regional surveillance systems by incorporating real-time event management systems. In this regard, Internet and new health informatics methods are revolutionizing how real-time information about public health events and outbreaks is exchanged and communicated nationally and globally. The World Health Organization Global Outbreak Alert and Response Network receives its information from different sources, including official and unofficial websites. The flow of outbreak information across national, regional, and subnational borders has improved the timely detection and recognition of the geographic extent of potential outbreaks.

A Pan American Health Organization/World Health Organization report (103) indicated that, from January 6 to March 7, 2007, of the 57 public health events verified by the Pan American Health Organization in Latin American countries, most of the sources (57%) originated from “unofficial sources,” such as the Global Public Health Intelligence Network/ProMED/media.

A large and expanding quantity of real-time information about outbreaks is now available in the Web-based networks and platforms as presented in the previous section of this review. However, the extensive amount of information available on the Internet requires ad hoc official verification and validation protocols, as illustrated by the Pan American Health Organization report.

Validation protocols and quality control measures are needed for the recognition of epidemiologic and health data and laboratory confirmation. These protocols are relevant for all sources of information: the traditional reporting systems, the syndromic surveillance, and the unofficial websites and other sources.

However, this important area of global surveillance is still developing. In many countries, there are still no clearly established guidelines for how countries should conduct the different types of surveillance, including real-time surveillance and which types of emerging disease syndromes should be confirmed and reported. Another important recognized challenge is the area of global surveillance enforcement.

Table 3 shows the World Health Organization’s 2009 definition of phases for the Pandemic Influenza Preparedness and Response. This definition was published in April 2009 and is part of the ongoing release of guidelines by the World Health Organization under the new IHR-2005.

Most publications and official reports have recognized that one critical aspect for effective global surveillance is the use of standardized protocols, guidelines, and case definitions.

In the case of novel or emerging diseases such as the pandemic spread of H1N1 influenza, the World Health Organization, with the assistance of international collaborative centers and recognized academic and scientific leaders, prepared specific guidelines for the surveillance of human infection with influenza A (H1N1) virus (104). The use of networks and the Internet has facilitated in a few hours the rapid dissemination of these guidelines around the globe. This type of protocol includes information about the main

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Table 3. WHO Pandemic-Phase Descriptions for Global Influenza Virus

<table>
<thead>
<tr>
<th>Pandemic Phase</th>
<th>Description</th>
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<tbody>
<tr>
<td>Phase 1</td>
<td>No animal influenza virus circulating among animals has been reported to cause infection in humans.</td>
</tr>
<tr>
<td>Phase 2</td>
<td>An animal influenza virus circulating in domesticated or wild animals is known to have caused infections in humans and is therefore considered a specific potential pandemic threat.</td>
</tr>
<tr>
<td>Phase 3</td>
<td>An animal or human-animal influenza reassortant virus has caused sporadic cases or small clusters of disease in people but has not resulted in human-to-human transmission sufficient to sustain community-level outbreaks.</td>
</tr>
<tr>
<td>Phase 4</td>
<td>Human-to-human transmission of an animal or human-animal influenza reassortant virus able to sustain community-level outbreaks has been verified.</td>
</tr>
<tr>
<td>Phase 5</td>
<td>The same identified virus has caused sustained community-level outbreaks in 2 or more countries in 1 WHO region.</td>
</tr>
<tr>
<td>Phase 6</td>
<td>In addition to the criteria defined in phase 5, the same virus has caused sustained community-level outbreaks in at least 1 other country in another WHO region.</td>
</tr>
<tr>
<td>Post-peak period</td>
<td>Levels of pandemic influenza in most countries with adequate surveillance have dropped below peak levels.</td>
</tr>
<tr>
<td>Post-pandemic period</td>
<td>Levels of influenza activity have returned to the levels seen for seasonal influenza in most countries with adequate surveillance.</td>
</tr>
</tbody>
</table>

Abbreviation: WHO, World Health Organization.

objectives of the surveillance for this specific influenza virus, including case definitions for confirmed and probable cases. Guidelines for the types of laboratory tests and reporting mechanisms are also now included for the designated national focal points. Countries without laboratory capacity for case confirmation are urged to contact the World Health Organization for coordinating the access to laboratories with this confirmation capacity.

Several guidelines have been proposed for the evaluation of surveillance systems (105–107). However, these evaluation guidelines were prepared before the implementation of the IHR-2005, and they need to incorporate the new information and reporting mechanisms and types of surveillance.

As presented in previous sections, new approaches using open-source and public-domain information have expanded rapidly during the last few years. They are seen as an important complement to current epidemiologic surveillance methods. These novel approaches use different models for examining and assessing biologic events or diseases with epidemic potential for outbreaks or pandemics (108–112).

Most of these approaches are using models based on algorithms of keywords fitting the parameters of the selected surveillance model for determining what constitutes an indication of disease occurrence or warning signal. To avoid potential confounders and high false-positive signals, different methods of filtering the information and contrasting it with simulated or historical outbreaks have been proposed and used. The objective of the assessment of the validity and reliability of the models is to significantly improve the sensitivity and early detection capabilities of the system while maintaining a level of specificity. Considerations from trade-offs of timeliness of detection and sensitivity and specificity are always needed to be evaluated. Shmueli (113) published a useful discussion of the main statistical methods for monitoring and evaluating data streams for biosurveillance.

The World Health Organization/Pan American Health Organization and the CDC have prepared generic guidelines for assisting countries in evaluating the efficiency and success of different national surveillance systems (114). A number of “process indicators” and “outcome indicators” have been proposed for the performance evaluation of these systems. For the sentinel surveillance, it is recommended that nationwide surveillance reviews be conducted at local or at intermediate levels to ensure data quality, protocol adherence, and standardization across the country at least once a year. The guidelines recommend reviews of all the notifiable disease reports (official and unofficial) and actions taken. This includes the review of all investigations with a focus on each component of the outbreak response (e.g., clinical, epidemiologic, veterinary, laboratory, and communications). Quality assurance mechanisms and continuing education concerning notifiable disease surveillance and sentinel surveillance are also recommended. Examples of proposed performance indicators for the evaluation of influenza sentinel surveillance are presented in Table 4.

The need for standardized case definitions in global and national surveillance is promoted by all health agencies and the surveillance community. The World Health Organization and most national and international health agencies have included standard case definitions on their websites and in documents for the known diseases and public health events. However, as mentioned above, for novel and emerging diseases and new public health events, there is a need for global guidelines from the World Health Organization. There is a provision in the IHR-2005 to include surveillance and notification of public health events of international importance, even if the causative agent is not yet known.

**DISCUSSION**

After the severe acute respiratory syndrome pandemic and during the current pandemic of H1N1 influenza, there has been an explosion of publications with a wealth of information about the implementation of better global health reporting and surveillance mechanisms, and thousands of websites have included information and guidelines on how to respond to community outbreaks and pandemics.

Discussions on global health and the issues of surveillance and control of major communicable diseases and the monitoring of security events are being documented in greater numbers in many scientific, technical, and political documents. Media reports are increasing their messages and programs about the national relevance of global health problems.

For some public health leaders, global health is a moral imperative (115). For some governments, investment in global health is a matter of self-interest because most global disease outbreaks, including pandemic flu, do not respect national borders. The World Health Organization, World Bank, CDC (US, Canadian, and European), US Agency for International Development, Fogarty International, and other important global health organizations and donors are joining in the efforts to expand the global network of health surveillance and training centers of excellence.

In the context of global health, surveillance refers to the systematic and ongoing collection, analysis, dissemination, and sharing of relevant information related to public health events of international importance to assist in deploying specific public health and security responses.

Surveillance is also recognized as the single most important public health instrument for identifying public health events of global concern, particularly infectious diseases that are emerging. Global health surveillance is essential to estimate the burden distribution and trends over time of health events causing serious public health risks and problems. Surveillance is especially important for the prompt identification of outbreaks and their source, which is crucial in the effective public health response needed in all affected countries. The new global surveillance also supports greater global health security assessments and control practices.

The IHR-2005 are a legally binding global accord adopted by all World Health Organization member countries and entered into force in June 2007. Country members are required to report to the World Health Organization all events resulting in public health emergencies of international importance. The compulsory notification includes any new event that constitutes a public health risk. In addition, the IHR-2005 include obligations for the establishment of national capacity to detect and respond to public health threats, emphasizing the
importance of real-time data dissemination. To coordinate the reporting process, the World Health Organization has created IHR contact point professionals for the appointed national IHR focal points. Ensuring compliance by poor countries will require important economic support and technical cooperation from wealthy countries and organizations.

A comprehensive global surveillance assessment prepared by the US Government Accountability Office concluded that, for many decades, global surveillance has been done through a “loose framework of formal, informal, and ad-hoc arrangements characterized as a network of networks” (71, p. 2). However, this “loose network” has been transformed in recent years by the international health community improvement of the global disease surveillance framework and by introduction of more systematic mechanisms to investigate, assess, and declare when and where there is a new “Public Health Emergency of International Concern” mentioned in the new IHR-2005.

There is agreement among the different reviewed professional assessments that key constraints and challenges for global public health are as follows:

1. The development of core capacities for new surveillance and response systems for developing countries is affected by the lack or shortages of resources, limited trained national staff and officials, and weak networks of laboratories.
2. Many countries have multiple independent surveillance and health information systems with limited coordination and no interoperability.
3. Laboratory facilities in many developing countries are not familiar with quality assurance and control principles and regulations, and a large percentage of their equipment is obsolete or not functioning.
4. Joint surveillance protocols and innovative systems of early detection of emerging diseases of animal origin that might threaten human health are needed. There is also a pressing need to have better integration and close collaboration of zoonotic and human surveillance systems.
5. The global disease monitoring through automated classification and visualization of events using electronic means is a limited option in many countries where the technologic divide is extreme. Large numbers of countries or areas in the interior of the countries have no access to the Internet or to basic computerized systems.
6. Local health facilities in a large number of countries have limited operating telecommunications and transportation capabilities available.
7. Traditionally, official surveillance systems are operated by staff not linked to the response teams, and the information collected is outdated and fragmented.
8. Many countries with severe human rights protection problems have difficulty maintaining the principles of fairness, objectivity, and transparency.
9. Compliance with global health regulations will require constant economic and technical cooperation with poorer countries.

The unique situation of global health and security surveillance will require closer collaboration among countries and the World Health Organization. However, because of the comprehensive response needed to address most security and disasters events and disease outbreaks, cooperation and coordination within countries of the health sector with all other sectors (police, fire fighters, transportation, housing, work and school, food, and others) and the civil society are of particular importance for the success of public health responses.

As reported by Heymann and Rodier (116), the experiences of several outbreaks during the last part of the 20th century, including cholera in Latin America, pneumonia...
plague in India, and Ebola hemorrhagic fever in the Democratic Republic of the Congo, have illustrated the consequences of delayed national detection and response. In addition, they demonstrated the need for better global surveillance and response mechanisms. The recent outbreaks of severe acute respiratory syndrome and the influenza A (H1N1) pandemic provide evidence of the benefits of the new global monitoring and of the importance of the World Health Organization in its coordinating role in the multilateral response of the global public health community.

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