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Public Health Informatics

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Learning Objectives

- Define public health informatics
- Define public health surveillance and how data is used in public health
- Explain the significance of information technology in the field of public health
- Explain the significance of syndromic surveillance for early detection of bioterrorism, emerging diseases and other health events
- Explain the significance and scope of global public health informatics
- Understand the workforce needs and competencies of a public health informatician
- List several of the current surveillance systems used in the field of public health
- Explain the function and purpose of the Public Health Information Network

Introduction

Public health is another medical sector that has been greatly influenced by advances in information technology over the past two decades. The overarching goal has been to monitor a variety of medical diseases and conditions rapidly and accurately so as to intervene as early as possible to detect, prevent, and mitigate the spread of epidemics, the effects of natural disasters, and bioterrorism. With the advent of the internet, ubiquitous computing, electronic health records and health information organizations this vision is now possible.

For much of the 20th Century, public health reporting and surveillance consisted of physicians, hospitals and clinics sending paper reports to local health departments, who in turn forwarded information to state health departments who sent the final data to the Centers for Disease Control and Prevention (CDC) via mail or fax and finally to the World Health Organization for certain diseases. Although paper reports are still used, the shift to electronic media and information technology has facilitated-more efficient methods of public health surveillance, community based outbreak detection and disease control.

The most critical component in any disease investigation is the availability of timely data and information to pinpoint the possible source of the outbreak. The proliferation of information technology into public health and medical fields have significantly improved disease surveillance and enhanced early detection of community or population based epidemics. Global events, ranging from the September 11, 2001 terrorist attacks, the emergence of severe acute respiratory syndrome (SARS) in 2002 in China, to the recent global H1N1 influenza outbreak reinforced the need for roburst interoperable surveillance systems. The terrorist events of September 11, 2001 in particular, the subsequent anthrax attacks across the United States elevated and reinforced public health to a national security issue increasing the need for biosurveillance and real-time data analysis to detect and respond to disease outbreaks and health events more rapidly.

In the following sections we will define public health informatics (PHI), discuss public health surveillance systems, discuss syndromic surveillance, geographic information systems and cover global public health informatics.

Definitions

- Public health: the science and art of preventing disease, prolonging life and promoting health through the organized efforts and informed choices of society, organizations, public and private, communities and individuals." [1]
- Public health informatics: "the systematic application of information and computer science and technology to public health practice, research and learning...." [2]
- Public health surveillance: "the ongoing systematic collection, analysis, and interpretation of health-related data essential to the planning, implementation and evaluation of public health practice, closely integrated with the timely dissemination of these data to those who need to know. The final link in the surveillance chain is the application of these data to prevention and control."[3]
- Syndromic surveillance: "surveillance using health-related data that precede diagnosis and signal a sufficient probability of a case or an outbreak to warrant further public health response."[4]

Public Health Surveillance

Public health surveillance is essential to understanding the health of a population. Until recent years, public health surveillance was primarily paper-based. However, with the increasing shift towards eHealth public health surveillance has embraced the field of public health informatics. [19] In order to study a large population we need interoperable technologies such as standards-based networks, databases and reporting software. Current electronic surveillance systems employ complex information technology and embedded statistical methods to gather and process large amounts of data and to display the information for networks of individuals and organizations at all levels of public health. Public health surveillance serves to:

- Estimate the significance of the problem
- Determine the distribution of illness
- Outline the natural history of a disease
- Detect epidemics
- Identify epidemiological and laboratory research needs

- Evaluate programs and control measures
- Detect changes in infectious diseases
- Monitor changes in health practices and behaviors
- Assess the quality and safety of health care, drugs, devices, diagnostics and procedures
- Support planning [13]

Types of Surveillance Systems

Public health surveillance systems can be classified based on data collection purpose and design. Table 23.1 demonstrates the more common categories. [14-18]

Table 23.1: Types of Surveillance Systems

Surveillance System	Definition/Description	Examples
Case surveillance systems	• Collect data on individual cases of a health event or disease with previously determined case definitions in respect to criteria for person, time, place, clinical & laboratory diagnosis • Analyze case counts and rates, trends over time and geographic clustering patterns • Historically, case surveillance has been the focus of most public health surveillance.	• National Notifiable Disease Surveillance System (NNDSS)
Syndromic surveillance systems	• Collect data on clusters of symptoms and clinical features of an undiagnosed disease or health event in near real time allowing for early detection, rapid response mobilization and reduced morbidity and mortality • Data can be obtained through specific surveillance systems as well as existing epidemiologic data such as insurance claims, school and work absenteeism reports, over the counter (OTC) medication sales, consumer driven health inquiries on the Internet, mortality reports and animal illnesses or deaths for syndromic surveillance. • Geographic and temporal aberration and geographic clustering analyses are performed with real-time syndromic surveillance data. • Syndromic surveillance systems can also be used to track longitudinal data and monitor disease trends.	• • Real-time Outbreak Detection System (RODS) • Biosurveillance Common Operating Network (BCON) • BioSense 2.0
Sentinel surveillance systems	• Collect and analyze data from designated agencies selected for their geographic location, medical specialty, and ability to accurately diagnose and report high quality data. They include health facilities or laboratories in selected locations that report all cases of a certain health event or disease to analyze trends in the entire population. • Pros: Useful to monitor and identify suspected health events or diseases • Cons: Less reliable in assessing the magnitude of health events on a national level as well as rare events since data collection is limited to specific geographic locations.	• PulseNet • FoodNet • ILINet
Behavioral surveillance systems	• Collect data on health-risk behaviors, preventative health behaviors, and health care access in relation to chronic disease and injury. • Analyze the prevalence of behaviors as well as the trends in the prevalence of behaviors over time. • Information is most commonly collected by personal interview or examination • Inferential and descriptive analysis methods such as age-adjusted rates, linear regression, and weighted analyses are used. • Most acute when conducted regularly, every 3 to 5 years	• Behavioral Risk Factor Surveillance System (BRFSS) • Youth Risk Behavior Surveillance System (YRBSS) • National Health Interview Survey (NHIS) • Pregnancy Risk Assessment Monitoring System (PRAMS)

Surveillance System	Definition/Description	Examples
Integrated Disease Surveillance and Response (IDSR)	• Incorporates epidemiologic and laboratory data in systems designed to monitor communicable diseases at all levels of the public health jurisdiction, particularly in Africa. • Useful for: detecting, registering and confirming individual cases of disease; reporting, analysis, use, and feedback of data; and preparing for and responding to epidemics.	
Clinical Outcomes Surveillance	• Monitors clinical outcomes to study disease progression or regression in a population. • Analyzes the rates of and factors associated with clinical outcomes using descriptive and inferential methods such as incidence rates from probability samples	• Medical Monitoring Project that monitors and tracks HIV patients
Laboratory Based Surveillance	• Collects data from public health laboratories, which routinely conduct tests for viruses, bacteria, and other pathogens. • Used to detect and monitor infectious and food-borne diseases based on standard methods for identifying and reporting the genetic makeup of specific disease-causing agents. • Commonly used in case surveillance and sentinel surveillance	• PulseNet • National Case Surveillance for Enteric Bacterial Disease (CDC)

The CDC has a helpful web page dedicated to surveillance programs for state, tribal, local and territorial public health officials. [19]

Syndromic Surveillance

Syndromic surveillance is part of meaningful use; therefore a basic understanding is important. Syndromic surveillance means symptoms are monitored (like diarrhea or cough) before an actual diagnosis is made. If, for example, multiple individuals complain of stomach symptoms over a short period of time, one can assume there is an outbreak of gastroenteritis. The important thing to remember is that syndromic surveillance systems do not identify the cause of the outbreak, rather they provide data comparisons which allows public health official to initiate outbreak investigation techniques.

In addition to the obvious sources of health data, public health officials can also monitor and analyze: unexplained deaths, insurance claims, school absenteeism, work absenteeism, over the counter medication sales, Internet based health inquiries by the public and animal illnesses or deaths. [15]

Initially, public health officials were very interested in detecting trends or epidemics in infectious diseases, such as severe acute respiratory syndrome (SARS) and avian influenza. After the terrorist attacks and anthrax outbreak in 2001, they have had to improve biosurveillance to detect bioterrorism. The objective is to "identify illness clusters early, before diagnoses are confirmed and reported to public health agencies and to mobilize a rapid response, thereby reducing morbidity and mortality."[20] The challenge is to develop elaborate systems that can sort through the information and reduce the signal to noise ratio. The syndrome categories most commonly monitored are:

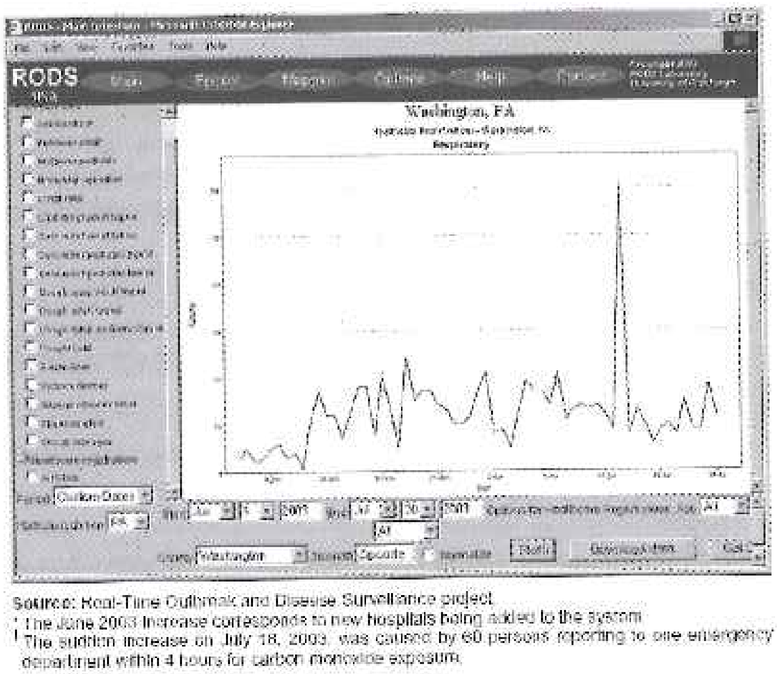
- Botulism-like illnesses
- Febrile (fever) illnesses (influenza-like illnesses)
- Gastrointestinal (stomach) symptoms
- Hemorrhagic (bleeding) illnesses
- Neurological syndromes
- Rash associated illnesses
- Respiratory syndromes
- Shock or coma

Ambulatory electronic health records (EHRs) are a potentially rich source of data that can be used to track disease trends and biosurveillance. EHRs contain both structured (e.g. ICD-9 coded) data as well as narrative free text. Hripcsak et al. assessed the value of outpatient EHR data for syndromic surveillance. Specifically, they developed systems to identify influenza-like illnesses and gastrointestinal infectious illnesses from Epic® EHR data from 13 community health centers. The first system analyzed structured EHR data and the second used natural language processing (MedLEE processor) of narrative data. The two systems were compared to influenza lab isolates and to a verified emergency room (ER) department surveillance system based on "chief complaint." The results showed that for influenza-like illnesses the structured and narrative data correlated well with proven cases of influenza and ER data. For gastrointestinal infectious diseases, the structured data correlated very well but the narrative data correlated less well. They concluded that EHR structured data was a reasonable source of biosurveillance data. [21]

Real-Time Outbreaks Detection System (RODS)

The RODS system was initially developed by researchers at the University of Pittsburg and was the first real-time detection system for outbreaks. RODS collected patient chief complaint data from eight hospitals in a single health-care system via Health Level 7 (HL7) messages in real time, categorized these data into syndrome categories by using a classifier based on International Classification of Diseases, Ninth Revision (ICD-9) codes, aggregated the data into daily syndrome counts and analyzed the data for anomalies possibly indicative of disease outbreaks. Much like the ESSENCE system, RODS system started with a set of mutually exclusive and exhaustive categories of eight syndromic categories. However, as the program has gone through revisions and refinement, the categories have been reduced to seven as follows: respiratory, gastrointestinal, botulinic, constitutional, neurologic, rash and hemorrhagic. Figure 23.1 shows the daily counts of respiratory cases for Washington County, PA in the period June-July 2003.

Figure 23.1: Daily counts of respiratory cases six month period, Washington County, PA 2003.



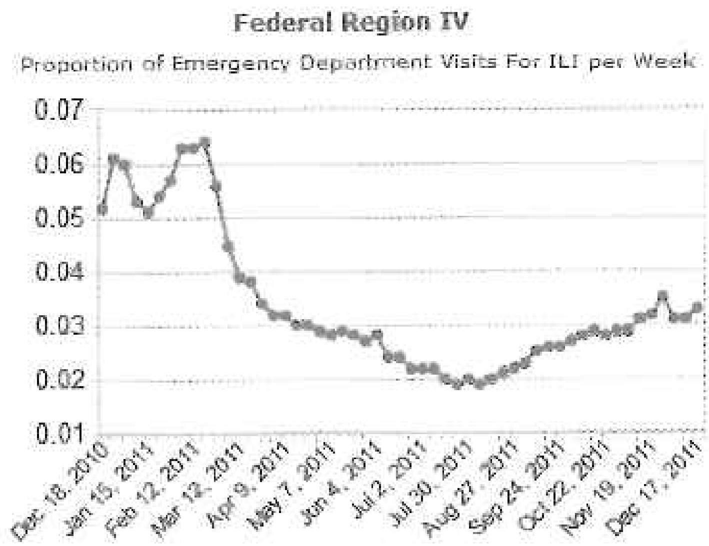
Source: Real-Time Outbreak and Disease Surveillance project
* The June 2003 increase corresponds to new hospitals being added to the system
† The sudden increase on July 18, 2003, was caused by 60 persons reporting to one emergency department within 4 hours for carbon monoxide exposure.

In order to increase the adoption of the RODS system, the University of Pittsburg started offering software free of charge to public health departments. In 2003 the software was offered under an open source license and since then many more agencies have adopted the software for their use.[22]

Distribute

This project was created by the International Society for Disease Surveillance (www.syndromic.org), with the goal of supporting emergency department (ED) surveillance of influenza like illnesses (ILI). Figure 23.2 shows ILI reported over the last year in south eastern United States (region IV). [23]

Figure 23.2 Proportion of ED visits for ILI weekly 2011 (Courtesy Distribute)



BioSense

This is a CDC national web-based program to improve disease detection, monitoring and situational awareness for healthcare organizations in the United States by reporting emergency room data. Participants include DOD, VA and civilian hospitals. The program addresses identification, tracking and management of naturally occurring events as well as bioterrorism. In 2010 BioSense was redesigned to integrate existing syndromic surveillance systems and allow for better regional sharing of information. The 2011 BioSense 2.0 allows state and local health departments to access data that will support syndromic surveillance systems under meaningful use. The goal is to provide a web based clearinghouse where data can be stored, searched and analyzed from and by multiple parties; decreasing the need for local health departments to purchase additional expensive information technologies.[24]

The Public Health Information Network

The Prevention and Public Health Fund, as part of the Affordable Healthcare Act of 2010, in conjunction with the Health Information Technology for Economic and Clinical Health (HITECH) Act has allowed the public health infrastructure to move into the eHealth era. Driven by the mission to prevent, reduce and treat disease, these initiatives focus on developing interoperable public health information systems that are beneficial to the healthcare of all Americans.[5-6]

The Public Health Information Network (PHIN) is a Centers for Disease Control and Prevention (CDC) initiative established to provide the framework for efficient public health information access, exchange, use, and collaboration among multi-level public health agencies and partners using a consensus of shared policies, standards, best practices, and services.[7]

Establishing messaging and vocabulary standards is a key strategy for PHIN, allowing for consistent interoperability between local, state and national public health entities as well as other agencies. The PHIN is currently working with the following Standard Development Organizations (SDOs): Systematic

Nomenclature for Medicine (SNOMED), Logical Observation Identifiers Names and Codes (LOINC), Health Level 7 (HL7), and Consolidated Health Informatics Initiative (CHI).[8] For more information about data standards, we refer readers to Chapter 6.

Electronic Health Records

Integral to this vision is interoperability with electronic health records (EHRs), as part of Meaningful Use of Health IT. As stated in the chapter on EHRs, Meaningful Use Stage 1 has several menu objectives with public health implications: the capability to transmit syndromic surveillance data to public health agencies, the capability to transmit data to immunization registries, and the capability for hospitals to transmit required disease Electronic Laboratory Reports (ELRs). [10]

As we see increased adoption of EHRs in the US and progression to Meaningful Use Stages 2 and 3, we should start to see new sources of data available for public health analysis. [10]

> **Public Health Information Network Update**
>
> On October 18, 2011, the "PHIN Messaging Guide for Syndromic Surveillance: Emergency Department and Urgent Care Data Version 1.0" was released, reaching a milestone for the public health objectives of Meaningful Use under the HITECH Act. This guide provides the HL7 2.5.1 messaging standard for the use of emergency department data as syndromic surveillance. [9]

Health Information Exchange (HIE)

We anticipate more public health reporting as a result of Meaningful Use for EHRs but a broader approach would be aggregating EHR/data shared with a health information organization. For further information about health information exchange we refer readers to Chapter 5.

A recent article outlined use cases that demonstrate the utility of HIE in public health:

- Mandated reporting of lab diagnoses: there is a predefined list of *notifiable diseases* (e.g. TB) that would benefit from electronic transmission to public health. In spite of that many states still rely on paper and results must be mapped to a standard vocabulary such as LOINC. A health information organization (HIO) could ensure proper identification, archiving and mapping. Mandated reporting could also trigger an alert of reportable diseases.
- Non-mandated reporting of lab data: There are several infectious diseases of interest that are not on the notifiable list but ideally tracked by public health. Additionally, antibiotic resistance patterns should be reported and shared with public health. A community wide antibiogram could be developed to educate local physicians about optimal prescribing patterns.
- Mandated reporting of physician-based diagnoses: physicians are separately required to report certain *notifiable diseases* but reporting is highly variable. This could be made easier with EHR reporting to the local HIO that in turn reports to public health. Data standards would be essential and alerts to appropriate public health staff, infection control officers, etc. would be possible.
- Non-mandated reporting of clinical data: syndromic surveillance will require symptom-related data from EHRs and emergency departments (EDs) to be sent and analyzed.
- Public health investigation: public health officials could query the HIO for additional clinical or demographic (age, gender, location, etc.) information about a case of interest.

- Clinical care in public health clinics: clinicians who treat patients in public health clinics could potentially benefit from access to a HIO.
- Population-level quality monitoring: HIE has the potential to give public health officials a glimpse of the quality of medical care in their area without chart reviews, across multiple health care systems.
- Mass-casualty events: HIOs might serve as a single point of contact for victims of a mass casualty. A record locator service might be able to keep track of admissions, discharges and transfer (ADT) data for the victims and their families.
- Disaster medical response: HIOs have the potential to make available patient data during a disaster when paper records might be destroyed or unavailable.
- Public health alerting--patient level: Theoretically, public health departments could alert all clinicians in a HIO about a case of TB where follow up is lost, for example. Public health officials could also warn hospitals about unique cases of highly resistant infectious organisms, particularly when patients tend to seek medical care at multiple institutions.
- Public health alerting - population level: Clinicians could be warned about trends in the community, for example viral culture results or antibiotic resistance trends.[11]

Geographic Information Systems (GIS)

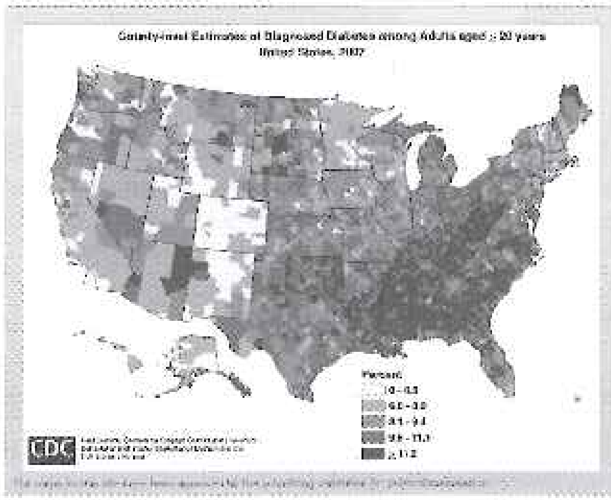
As early as 1855 Dr. John Snow created a simple map to show where patients with cholera lived in London in relation to the drinking water source in the Soho District of London. Using his hand drawn map and basic epidemiological investigation techniques, much of which are still used today, he determined the source of the epidemic to be a common water pump. Epidemiology, public health surveillance and indeed the field of public health have improved significantly since the pioneer work of Snow and others after him. Much of this transformation has been the result of the emergence and proliferation of advanced computing technologies, the internet and other automated information systems.

Modern geographic information systems (GIS) use digitized maps from satellites or aerial photography. A Geographic Information System (GIS) is a system of hardware, software and data used for the mapping and analysis of geographic data. GIS provides access to large volumes of data; the ability to select, query, merge and spatially analyze data; and visually display data through maps. GIS can also provide geographic locations, trends, conditions and spatial patterns. Spatial data has a specific location such as longitude-latitude, whereas attribute data is the database that describes a feature on the map.

GIS maps are created by adding layers. Each layer on a GIS map has an attribute table that describes the layer. The data can be of two types: *Vector* or *Raster*. *Vector* data appears as points, lines or polycons (enclosed areas that have a perimeter like parcels of land). *Raster* data utilizes aerial photography and satellite imagery as a layer. Using GPS and mobile technology, field workers can enter epidemiologic data to populate a GIS. This geospatial visualization has been useful in tracking infectious diseases, public health disasters and bioterrorism.[25,26]

With the recent shift in public health focus to preventable chronic diseases, GIS has also been used to monitor chronic diseases and social and environmental determinants of health for public health policy. In early 2011, the Centers for Disease Control and Prevention launched a new project, Chronic Disease GIS Exchange. Designed for public health professionals and community leaders, GIS experts will use as an information exchange forum to network and collaborate with the goal of preventing heart disease, stroke and other chronic diseases. Data and information shared in this forum will be used in documenting the disease burden, informing policy decisions, enhancing partnerships and facilitating interventions from the use of GIS data.[27-29] Figure 23.3 shows a GIS display of diabetes incidence rates by State. [28]

Figure 23.3: GIS Map of diabetes diagnosis by county (Courtesy CDC Chronic Disease GIS Exchange)



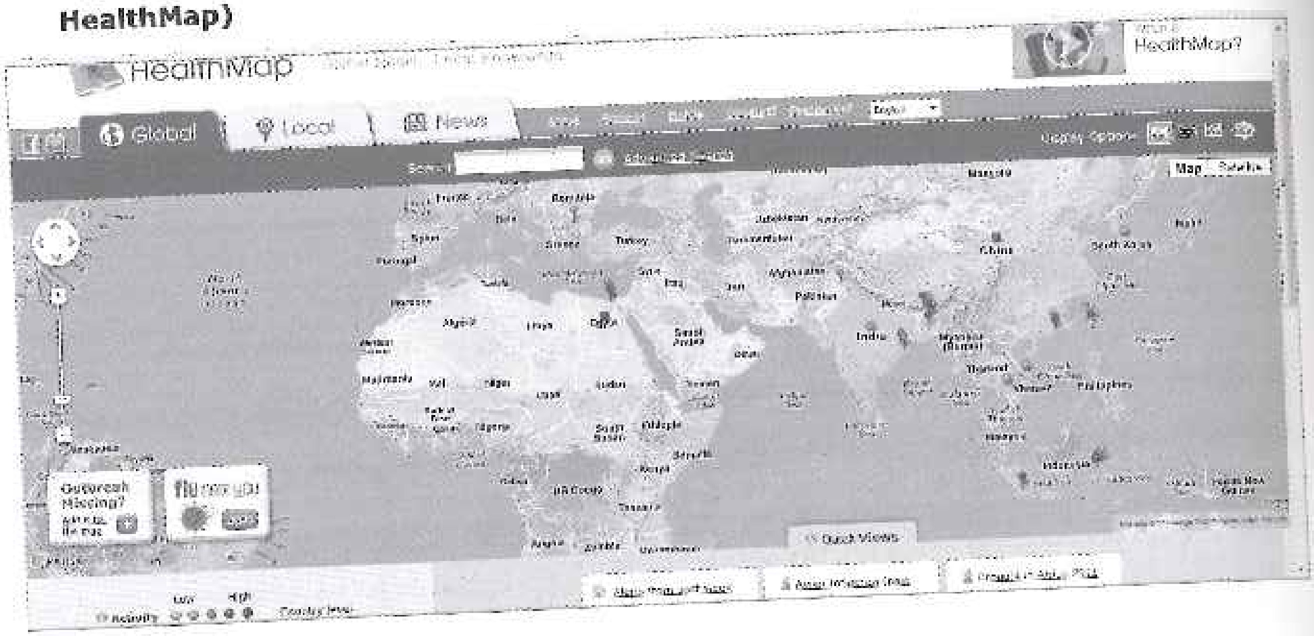
Virtually all of the biodetection systems mentioned have a GIS component that allows for the mapping of disease outbreak events giving public health practitioners the ability to timely deploy resources to control the outbreak and prevent further spread. Key variables can be inputted by zip code, latitude, longitude, that help public health disease investigators narrow down the source of the problem.

HealthMap is a global project to integrate infectious disease news and visualization using an Internet geographic map. This program classifies alerts by location and disease. For example, you can select "malaria" and "global" and see if there were any reported cases in the past 30 days. "Mouseover" an icon and you will see what is being reported in that area. A smartphone app "Outbreaks near me" details H1N1 (swine flu) outbreaks by locale, in near real time.[30] The program was developed by the Harvard-MIT Division of Health Sciences and Technology and a more detailed explanation of the system and architecture is provided at this reference.[31] Figure 23.4 shows a GIS display of global avian flu outbreaks

Public Health Informatics Workforce

As discussed, in order to most accurately and efficiently study the health of the population, information and communication technologies are essential to support the increasing demand for public health research and evidence based public health practice as a result of the aging US population. These technologies also require a diversity of human expertise for management, analysis, and communication of public health data. The Association of Schools of Public Health (ASPH) estimates that the field of public health will require 250,000 more workers by 2020 to avert a national public health crisis. [32] The transition to eHealth requires all public health workers to have some knowledge of IT depending on the demands of their position. In anticipation of this need, the CDC in collaboration with the University of Washington's School of Public Health and Community Medicine's Center for Public Health Informatics developed a list of informatics competencies for public health workers to meet the needs of the evolving public health field as well as for the Public Health Informatician. A Public Health Informatician is "a public health professional who works in practice, research, or academia and whose primary work function is to use informatics to improve population health."[33]

Figure 23.4: GIS display of global avian influenza outbreaks (Courtesy HealthMap)



Global Public Health Informatics

Public health threats from chronic and infectious diseases, population health status, and health disparities within and across countries have gained global attention in part due to increasing personal mobility, economic globalization, and expansion of communication technologies. In fact, the global threat from chronic diseases was the focus of the 2011 UN General Assembly. Infectious diseases, such as influenza, polio, and HIV/AIDS, can quickly spread across national borders and are best curtailed through international cooperation and timely information sharing. New or re-purposed health information technologies provide critical support in the identification, monitoring, alerting, and responding to emerging diseases, pandemics, bioterrorism, and natural disasters. Simultaneously, health informatics has also emerged as an important tool in addressing population health goals and as a means to reduce health disparities between *developed* and *developing* nations.

World Health Organization

The leading international public health entity is the World Health Organization (WHO). Organized in 1948 as an agency of the United Nations (UN), WHO directs and coordinates public health efforts worldwide. WHO and its 195 Member States collaborate with other UN agencies, nongovernmental organizations, and the private sector to:

- Foster health security: Through its surveillance and disaster/epidemic response systems, WHO works to identify and curb outbreaks of emerging or epidemic-prone diseases. The revised 2007 International Health Regulations address the major forces contributing to epidemics including urbanization, environmental mismanagement, food preparation, and the overuse of antibiotics.
- Promote health development: Through this objective WHO works to increase access to life-saving and health-promoting interventions, particularly in poor, disadvantaged, or vulnerable groups. WHO's health development efforts focus on the treatment of chronic and infectious disease (e.g. diabetes), prevention and treatment of tropical diseases (e.g. malaria), women's health issues, and healthcare within African nations.

- Strengthen health systems: In poor and medically underserved areas, WHO endeavors to strengthen and supplement existing health systems. Activities include providing trained healthcare workers, access to essential drugs, and assistance in collecting vital health information.[34]

As discussed throughout this section, WHO increasingly relies on health information technology to carry out its objectives.

International Surveillance and Response Programs

The most visible role of WHO is to detect and respond to infectious disease outbreaks, pandemics, and disaster emergencies. Global surveillance of infectious disease, famines, and environmental disasters is implemented through a network of regional, national, and international institutes.[32] Government organizations (e.g. CDC), military networks (e.g. US Department of Defense's Global Emerging Infections Surveillance and Response System), and a host of public and private non-governmental organizations (NGOs) (e.g. Google, HealthMaps) monitor and report infectious diseases to WHO. Additionally, internet sites such as Epi-X or Pro-Med maintain discussions on current infectious diseases.

A 2007 review of 15 international surveillance and response programs (ISRPs) classified their activities into four basic components: surveillance, reporting, verification, and response.[35] The report found that the majority of these ISRPs focus on surveillance and reporting, while only six carry out all four activities. These six ISRP as well as other leading surveillance systems are described in the Appendix.

Regardless of the surveillance component performed by an ISRP, these organizations have benefited from the expansion of health information technology into the surveillance arena. Over the past decade, WHO and ISRPs have embraced web-based computing, mobile applications, GIS, and even text messaging. The role of health informatics within the major global surveillance organizations are discussed below.

Global Alert and Response (GAR): GAR is the integrated infectious disease surveillance program within WHO. A network of national, regional, and international agencies, governmental organizations (e.g. CDC) and military networks (e.g. US Department of Defense's Global Emerging Infectious Disease), GARs primary function is the facilitation of epidemic preparedness and response worldwide. This body is also responsible for maintaining and enhancing the global outbreak and bio-risk operational platforms.[36] Global monitoring and coordination are increasingly important in light of recent public health challenges such as outbreaks of severe acute respiratory syndrome (SARS) and influenza A (H_1N_1), the AIDS epidemic, and emerging new diseases and pathogens. Electronic surveillance capabilities have greatly enhanced the ability of GAR and its component functions to identify and respond to public health emergencies. Subsidiary functions under GAR include:

- International Health Regulations: 2005 revisions to WHO's International Heath Regulations (IHR) are aimed at improving global public health security and collaborative response to natural disasters, biological or chemical agents, and radioactive material release.[37] This legally-binding agreement provides a framework for the management of international public health emergencies, while also addressing the capacity of participating nations to detect, evaluate, alert, and respond to public health events. IHR specifies operational procedures for disease surveillance, notification and reporting of public health events and risks as well as for the coordination of international response to those events. The 2005 IHR allowed for the first time non-governmental sources to provide surveillance information to WHO. Participation by non-governmental contributors is as a positive step that pushes WHO to become more "dynamic, flexible, and forward-looking."[38]

- Early Warning Surveillance: GAR implemented an early warning surveillance response (EWARN) mechanism to effectively identify disease outbreaks and other health issues immediately following acute emergencies. An initial version of the system has been in use in

Haiti since the 2008 hurricane and expanded following the devastating Haitian earthquake in 2010. The system monitored public health issues such as injuries, mental health concerns, TB and HIV treatment programs, and disease trends. Inconsistency of data reporting, lack of trained personnel for data collection and technological errors among other problems interfered with the project from the start.[39] One solution that was developed in response to these challenges was a "virtual Google group" set up to improve communication. In remote, undeveloped areas of the world, WHO has encouraged Member States to develop early warning systems that use a variety of media including fax, telephone, the internet, and SMS to connect district or national surveillance officers with field collection efforts.

Global Public Health Intelligence Network (GPHIN): GPHIN was developed by the Public Health Agency of Canada to electronically monitor infectious disease outbreaks. Approximately 40 percent of the outbreaks investigated by WHO each year come from the GPHIN. This network "is a secure, internet-based 'early warning' system that gathers preliminary reports of public health significance in seven languages on a real-time, 24/7 basis."[40] GPHIN "continuously and systematically crawls web sites, news wires, local online newspapers, public health email services and electronic discussion groups for key words.[41] Although originally developed to detect infectious disease outbreaks, GPHIN now scans for food and water contamination, exposure to chemical and radioactive agents, bioterrorism, and natural disasters. It uses automated analysis to process the gathered data to alert human analysts to conduct additional review of any serious issues or trends. These data are then made available to WHO/GOARN and other subscribers through its web-based Microsoft/Java application and to the public through the WHO web site. GPHIN's automated data has significantly accelerated global outbreak detection.

Malaysia: Early Warning And Risk Navigation Systems

eWARNS is Malaysia's Early Warning And Risk Navigation Systems for natural disasters including rainfall, flash flood, soil erosion, landslide, tidal wave, and forest fire. Remote Sensing and Transmission Units (RSTU) placed throughout the country are used to predict floods and other natural disasters. Each RSTU collects rainfall data, senses the impact of the rain, and transmits the data via the internet to a receiving unit. The RSTU also acts as a web-server allowing the 'remote panel' to be viewed via the internet. The system alerts the public to real time risk levels and forecasts via SMS text messaging on their mobile phones.10 Information on daily rainfall, erosivity index, and erosion hazards are also available on the website.

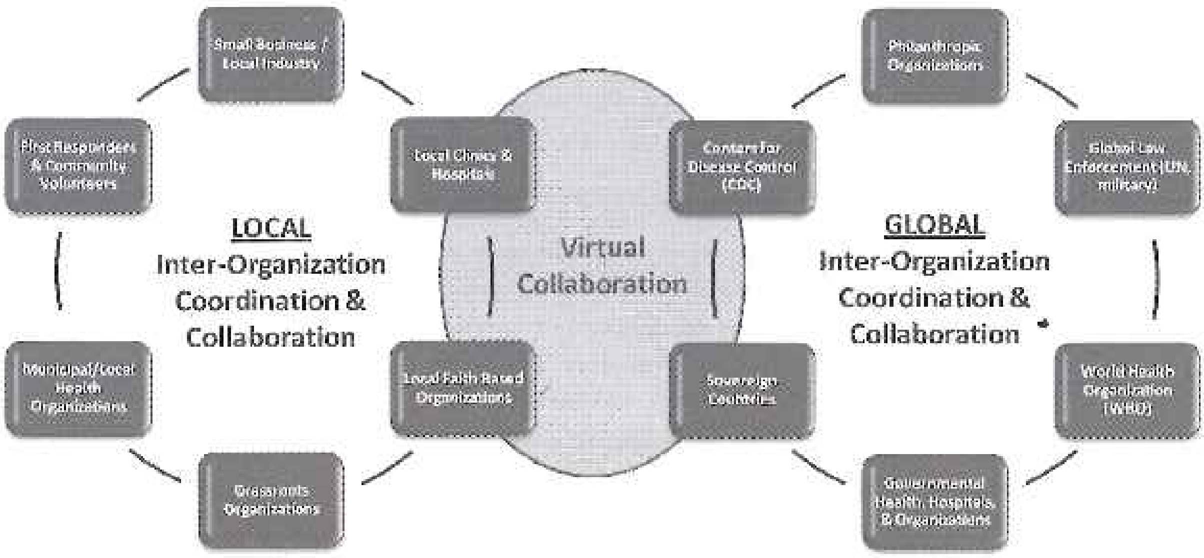
http://www.ewarns.com.my/index.php?im=about

Global Outbreak Alert and Response Network (GOARN): The Global Outbreak Alert and Response Network was established by WHO in 1997. GOARNS has 420 global partners to collaboratively provide a rapid identification and response to outbreaks and alert the international community. Collaboration is provided by organizations like the Red Cross, the United Nations, humanitarian and scientific institutions, technical networks, laboratories, and surveillance and medical initiatives.[42]

Since 2000 GOARN has responded to more than 50 events worldwide, including SARS, Avian influenza and H1N1 influenza outbreak. Over one third of the surveillance information coming into GOARN is provided by GPHIN. Other surveillance information is provided by governmental agencies, universities, military agencies, and non-governmental organizations (NGO), such as the Red Cross and Médecins sans Frontières (Doctors without Borders). To facilitate global coordination, GOARN has established standardized operating procedures to be used by Member States and partnering organizations for identifying and responding to outbreaks. Features of the system include: alerts to the international community about outbreaks and technical collaboration on the rapid identification and response to outbreaks.[42] WHO's state of the art IT and communications systems ensure secure timely communications within GOARN and between GOARN and Member States and partnering entities thus facilitating the quick response and control of disease outbreaks.

Effective communication and collaboration between local and global responders to public health crises, hazards, and pandemics, is critical to successfully address the complex and diverse needs of the population after a disaster or during a public health emergency. GOARN and other responders recognize the benefit of integrating information and communication technology (ICT) into current operations.[43] Although sharing protocols of ICT appear to be a challenge, the emerging field of community informatics seems to provide the potential for inclusion of local health providers in emergency response efforts coordinated by global public health agencies.[44] Figure 23.5 depicts the complex and interdependent communication that must occur to ensure coordination of the local and global public health entities involved in disaster or public health emergency response.

Figure 23.5: Coordination between local and global public health organizations



Other Global Public Health Activities

Surveillance and response to emergent health events maybe the most visible, but they are not the only functions of public health organizations. Public health is responsible for the prevention and control of disease, chronic and communicable diseases such as HIV/AIDS, TB, and polio and also plays a key role in health promotion and education. Historically, WHO and other public health organizations have struggled to provide even the most basic services to remote and poor areas around the globe. Health technology, particularly *mhealth*, has enabled public health agencies to reach out to isolated villages, connect with paraprofessional field workers, collect data, diagnosis disease, deliver disease management instructions, provide proficiency training to healthcare workers, and educate patients. Some of the organizations that deploy health technology in the fight to improve global health are identified in Table 23.2 on following page.

Global Health Information Technology Programs

Listed in alphabetical order below are a few of the premier organizations that facilitate the use of health information technology for public health:

- Center for Innovation in Global Health Technologies (CIGHT): A component of the Robert R. McCormick School of Engineering and Applied Science at Northwestern University, CIGHT collaborates with other universities, global healthcare companies, and non-profit organizations on the research and development of innovative and affordable healthcare technologies. The program focuses on three areas that are of concern in developing nations: HIV and associated diseases, saving lives at birth, and training healthcare workers to supplement physicians and nurses. http://www.eight.northwestern.edu/global-health-initiatives/index.html

- FHI360-SATELLIFE: Created in 1987, SATELLIFE is a leader in using information technology to connect healthcare providers in developing nations to vital medical knowledge. Its GATHERdata™ project uses mobile devices to collect, report, and analyze real-time disease surveillance data. http://www.healthnet.org/
- Global Public Health Informatics Program (GPHIP): The Centers for Disease and Control (CDC) established a Global Public Health Informatics Program (GPHIP) in 2008 to collaborate with WHO and other international partners. "The Goal of GPHIP is to improve domestic and international public health informatics programs and advance the best informatics science, principles, strategies, standards, and practices."[46] GPHIP assists CDC-supported countries on developing and implementing innovative public health informatics solutions. Collaborative projects supported by GPHIP include a mobile-based information system for use in health emergencies and for surveys in China, an electronic integrated disease surveillance systems (EIDSS) in cooperation with Armenia, Azerbaijan, Georgia, Kazakhstan, Saudi Arabia, Ukraine, and Uzbekistan, and a national disease surveillance (NDS) and a health surveillance network (HSN) in Saudi Arabia. http://www.cdc.gov/globalhealth/programs/informatics.htm
- Information and Communication Technologies for Public Health Emergency Management (ICT4PHEM): Established by GAR in 2009, ICT4PHEM "is a technical collaboration of existing institutions and networks who pool human, technical and technological resources together to provide enhanced ICT solutions to predict, prevent and support Public Health Emergencies."[47] The objective of ICT4PHEM is to deploy ICT in the detection, assessment, verification and response to public health threats throughout the world. The initial meeting was held in April 2009 to discuss the need to develop, enhance and make available ICT tools to public health entities worldwide. http://www.who.int/csr/ict4phem/en/index.html
- WHO Global Observatory for eHealth (GOe): In 2005, the 58th World Health Assembly recognizing the need to incorporate emerging health information technologies into WHO and Member States adopted an eHealth strategy resolution. That same year WHO established GOe to study the impact of ehealth. The GOe conducted a survey of members in 2005 to establish a benchmark for each nation on its ehealth; a follow-up survey was conducted in 2009. Information on their findings relative to mobile technology, telemedicine, safety and security and other ehealth issues are available on their website: http://www.who.int/entity/goe/.
- Wireless Reach™: Through its Wireless Reach™ program, Qualcomm works with global partners to bring wireless technology to poor and remote areas around the world. Wireless Reach™ addresses education, entrepreneurship, public safety, and environment in addition to health. Its projects tend to be telemedicine related, although some have public health applicability. http://www.qualcomm.com/citizenship/wireless-reach

Table 23.2: Global Efforts to Improve Public Health through the use of Health Information Technology

Organization	Public Health Informatics Services
Cell-Life http://www.cell-life.org/	A not-for-profit organization that deploys mobile technology in the fight against HIV and other communicable diseases, primarily in South Africa. It has effectively used SMS to encourage HIV testing, to remind women to continue in prevention programs to curb mother-to-child transmission of HIV, increase antiretroviral therapy adherence, and provide family planning information.
Datadyne http://www.datadyne.org/	Datadyne offers applications for the use of cell phones to collect data, sending of mass SMS messages, and to provide continuing education to healthcare workers in remote areas through mobile devices.
Dimagi http://www.dimagi.com/	Dimagi in a for-profit company that builds custom mobile health and SMS solutions for resource-poor environments. It offers Windows Mobile 5 software devices to assist community health workers to screen HIV/AIDS patients, personalized SMS medication reminders to increase antiretroviral adherence in HIV patients, a mobile solution to improve home-based cancer care coordination, a portable web application for remote clinics to send cancer screening images to hospital-based physicians, SMS alerts for critical events, mobile applications for continuing education of remote healthcare workers, and a mobile application to increase compliance with WHO's Integrated Management of Childhood Illness program by remote health workers.
E Health Point http://ehealthpoint.com/?page_id=77	This project uses telemedicine to connect rural Indian villages to physicians and evidence based healthcare.
Mobile Alliance for Maternal Action (MAMA) http://www.mobilemamaalliance.org/	MAMA is a public-private partnership involving the US Agency for International Development, Johnson & Johnson, the United Nations Foundation, mHealth Alliance and BabyCenter. MAMA uses mobile phones to send audio and text health messages and reminders to new and expectant mothers.
mHealth Alliance http://www.mhealthalliance.org/	The mHealth Alliance is a public-private partnership between the UN Foundation, the Rockefeller Foundation, and The Vodafone Foundation. Its purpose is to harness the power of wireless technologies to improve health outcomes in low and middle income countries.
WHITIA-Essential Technologies for Safety Net Providers http://www.worldhealthimaging.org/index.html	WHITIA developed a low-cost, simple to use, self-contained digital x-ray unit. These units were initially deployed in Guatemala. WHITIA also provides telemedicine technology to connect village medical personnel with specialists and technology to enable high speed transmission of teleradiology images and healthcare data.

Future Trends

At the core of public health informatics is surveillance, a practice that relies on near-real time, high quality data. Largely because of the increased global use of the Internet, we are seeing an increase in analysis of aggregated data collected by both public and private organizations such as Google and various social media sites like Twitter and Facebook. Google.org recently launched three Internet-based projects utilizing revolutionary technology for public health research and policy development: *Google Flu Trends, Google Dengue Trends*, and *Google Crisis Response*. *Google Flu Trends* and *Dengue Trends* use aggregated data based on Google search queries to estimate disease activity in real-time.[48-49] Correlating strongly with data from the CDC, *Google Flu Trends* data is estimated to precede CDC results by about one week. [50-51] Ultimately, this methodology may be shown to be the most effective and fastest way to identify pandemic flu. Another venue for data aggregation analysis is social media. By examining data aggregated by user posts, researchers are gaining insight into health perceptions and behaviors as well as early detection of potential disease trends. Though criticized early on for the possibility of false reports and lack of specificity and sensitivity, social media's freely available, "real time" and statistically significant data is becoming as an essential tool for disease surveillance. [52-53]

Case Study

Mobiles in Malawi was initiated in the summer of 2007, by Josh Nesbitt who was working with a "rural Malawian hospital that serves 250,000 patients spread 100 miles in every direction. To reach remote patients, the hospital trained volunteer community health workers (CHWs) like Dickson Mtanga, a subsistence farmer. Dickson had to walk 35 miles to submit hand-written reports on 25 HIV-positive patients in his community. The hospital needed a simple means of communication."[45] Seeing the need Josh returned to the hospital the following year with mobile phones and a laptop running *FrontlineSMS*. In late 2008, *Mobiles in Malawi* merged with *MobilizeMRS*, an electronic medical records initiative that trained CHWs in structured data collection. The coming together of these efforts resulted in the creation of *FrontlineSMS:Medic* whose "mission was to help health workers communicate, coordinate patient care, and provide diagnostics using low-cost, appropriate technology....

"In six months, the pilot in Malawi using *FrontlineSMS* saved hospital staff 1200 hours of follow-up time and over $3,000 in motorbike fuel. Over 100 patients started tuberculosis treatment after their symptoms were noticed by CHWs and reported by text message. The SMS network brought the Home-Based Care unit to the homes of 130 patients who would not have otherwise received care, and texting saved 21 antiretroviral therapy (ART) monitors 900 hours of travel time, eliminating the need to hand deliver paper reports."[45]

Frontline SMS:Medic has since been deployed in Haiti after the 2010 earthquake where it was used by frontline disaster relief workers to text message urgent needs. "Using crowd-sourced translation, categorization, and geo-tagging, reports were created for first responders within 5 minutes of receiving an SMS. Over 80,000 messages were received in the first five weeks of operation, focusing relief efforts for thousands of Haitians."[45]

"In less than one year, *FrontlineSMS:Medic* expanded from 75 to 1,500 end users linked to clinics serving approximately 3.5 million patients. Growing from the first pilot at a single hospital in Malawi, they established programs in 40% of Malawi's district hospitals and implemented projects in nine other countries, including Honduras, Haiti, Uganda, Mali, Kenya, South Africa, Cameroon, India and Bangladesh."[45]

Frontline SMS has developed other mobile tools including: *PatientView*, a lightweight patient records system, *TextForms*, a text-based information collection module, and a messaging module for *OpenMRS*. *FrontlineSMS:Medic* recently changed its name to *Medic Mobile*.

Key Points

- Public health informatics is an important sub-category of health informatics
- Public health reporting will be part of meaningful use stages 1-3
- Public health surveillance is very broad and covers infectious diseases, epidemics, natural disasters and bioterrorism
- Geographic information systems provide a convenient display of medical information overlaid on geographical interface
- A myriad of new national and global public health informatics-related initiatives have been established

Conclusion

Public health is concerned with the health of populations, instead of individuals. In order to study large populations and track trends in health and other public health activities, paper-based reporting is no longer tenable. A robust public health network will require data standards, electronic health records and health information exchange. As a result of the HITECH Act and Affordable Care Act we are moving closer to the ideal goal of almost real time public health surveillance and reporting.

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