

The Potential Utility of Electronic Disease Surveillance Systems in Resource-Poor Settings

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With the concern over emerging infectious diseases, such as avian influenza, and the inception of the recently modified World Health Organization's (WHO) International Health Regulations, there is a clear need for enhanced disease surveillance throughout the world but especially in resource-poor settings. To date, most electronic disease surveillance systems have been implemented in industrialized countries where there is greater accessibility to technology infrastructure and electronic data. However, although systems deployed in developing settings vary in sophistication, they still can succeed in establishing an early detection capability where one does not currently exist. Based on the systems research and implementation experience of APL and the international surveillance experience of the U.S. Department of Defense Global Emerging Infections Surveillance and Response System (DoD-GEIS), we have drafted a framework for consideration by system implementers as many member states try to come into compliance with the new WHO regulations.

INTRODUCTION

APL and the U.S. Department of Defense Global Emerging Infections Surveillance and Response System (DoD-GEIS), under DoD-GEIS sponsorship, evaluated existing surveillance systems in resource-limited settings and used information gained from these site visits to establish a framework for the implementation

of electronic disease surveillance systems in similar settings. APL, through its work on the development and deployment of the Electronic Surveillance System for the Early Notification of Community-based Epidemics (ESSENCE), is a recognized authority in the field of electronic disease surveillance systems.¹ Additionally,

as a U.S. Centers for Disease Control and Prevention (CDC) Center of Excellence in Public Health Informatics, APL is performing additional research to continue the advancement of specific techniques and methodologies being used in electronic disease surveillance systems. Given that instances of ESSENCE exist in numerous cities and states throughout the United States, the team at APL is experienced in assessing the different user environments—from gathering system requirements to reviewing functional capabilities. It is this intimate knowledge of systems and system users that the APL/DoD-GEIS team is known for and is now employing in this new application of electronic disease surveillance.

Per Presidential Decision Directive NSTC-7,² the DoD-GEIS has the mission to support global surveillance, training, research, and response to emerging infectious disease threats. Through coordination at the GEIS central hub, enhanced preventive health programs and epidemiological capabilities, and enhanced involvement with military treatment facilities in the United States and overseas laboratories, the DoD has strengthened its role in the global health community. This role has provided the DoD-GEIS with the on-the-ground experience and knowledge of the international environment into which electronic disease surveillance tools are being deployed.³

APL and DoD-GEIS are bringing their expert knowledge of electronic surveillance systems and international disease surveillance together for the purposes of evaluating systems that currently are operating in resource-poor settings. This information, combined with experience in other domestic and international settings, is being used to develop a framework for understanding how to construct templates for electronic disease surveillance systems in developing countries.

This paper will focus on general concepts to be considered by system implementers as they evaluate the use of various electronic disease surveillance system components to be used in a particular setting. Examples of such systems will be provided for the purpose of illustration only.

BACKGROUND

Emerging and re-emerging infectious diseases continue to be a serious public health threat in the world today, with the World Health Organization (WHO) identifying more than 1100 epidemic events worldwide in the last 5 years.⁴ Of most recent interest in the United States and other industrialized nations has been the emergence of avian influenza H5N1, which first surfaced in 1997 and continues to be a concern in Southeast Asia. For example, Indonesia has experienced 113 cases and 91 deaths since 2003, and Vietnam has experienced 100 cases and 46 deaths.⁵ Although not readily transmissible from person to person at this time, the threat of

this possibility, or of a different influenza strain growing to pandemic proportions, has made many people fearful in recent years.⁴ The outbreak of severe acute respiratory syndrome (SARS) in 2003, which quickly traversed the globe, causing major outbreaks both in Asia and in Canada, demonstrated just how easily novel respiratory pathogens could spread.⁶ This should not be surprising considering the extensive air and trade routes that are in use today (Fig. 1)⁷ and the fact that there were approximately 2.1 billion airline passengers who traveled in 2006.⁴ Air travel is readily accessible to many people in today's world; therefore, much work has been done in recent years to assess the role of airline travel on the spread of infectious disease.^{6–8} Similarly, many models have been developed that estimate how to contain the spread of an epidemic once it has taken hold in a community.^{9,10}

These infectious disease events, combined with the fear of a manmade biological or chemical attack, spurred the WHO to update the International Health Regulations. These regulations were last modified in 1969 and only identified yellow fever, plague, cholera, and smallpox as diseases that must be reported by member countries. Therefore, in 2005, the WHO completed a 10-year effort to modify these regulations. The five key areas of modification of the International Health Regulations were (i) expanded scope of reportable diseases, (ii) implementation of a decision-support instrument, (iii) enhanced communication, (iv) improved national surveillance and response capacities, and (v) WHO support.¹¹ As summarized in Table 1, the aim of the new requirements is to assist the WHO member countries as they begin to reassess their surveillance and response programs in WHO's effort to enhance overall global public health security.¹¹

Improving a country's overall surveillance and response capacities is where an electronic disease surveillance system can facilitate their efforts. Novel surveillance approaches in many industrialized nations focus on the use of nontraditional data sources, such as emergency department chief complaints, school absentee data, and over-the-counter pharmaceutical data to provide an early indication of anomalous health events. Such systems rely on prediagnostic data grouped into syndrome categories, which can identify potential problems and situational awareness to a community. Although originally developed in the late 1990s to detect a manmade biological attack resulting from a terrorist act, these systems have proved useful in monitoring for various naturally occurring illnesses such as influenza, gastrointestinal disease, and others.¹² It was believed that in order for an electronic surveillance system to be useful for both early detection and situational awareness during a biological attack, it would be necessary for this system to be used on a daily basis by public health professionals. As a result, these systems have become multi-use tools in health departments in the United States as a means

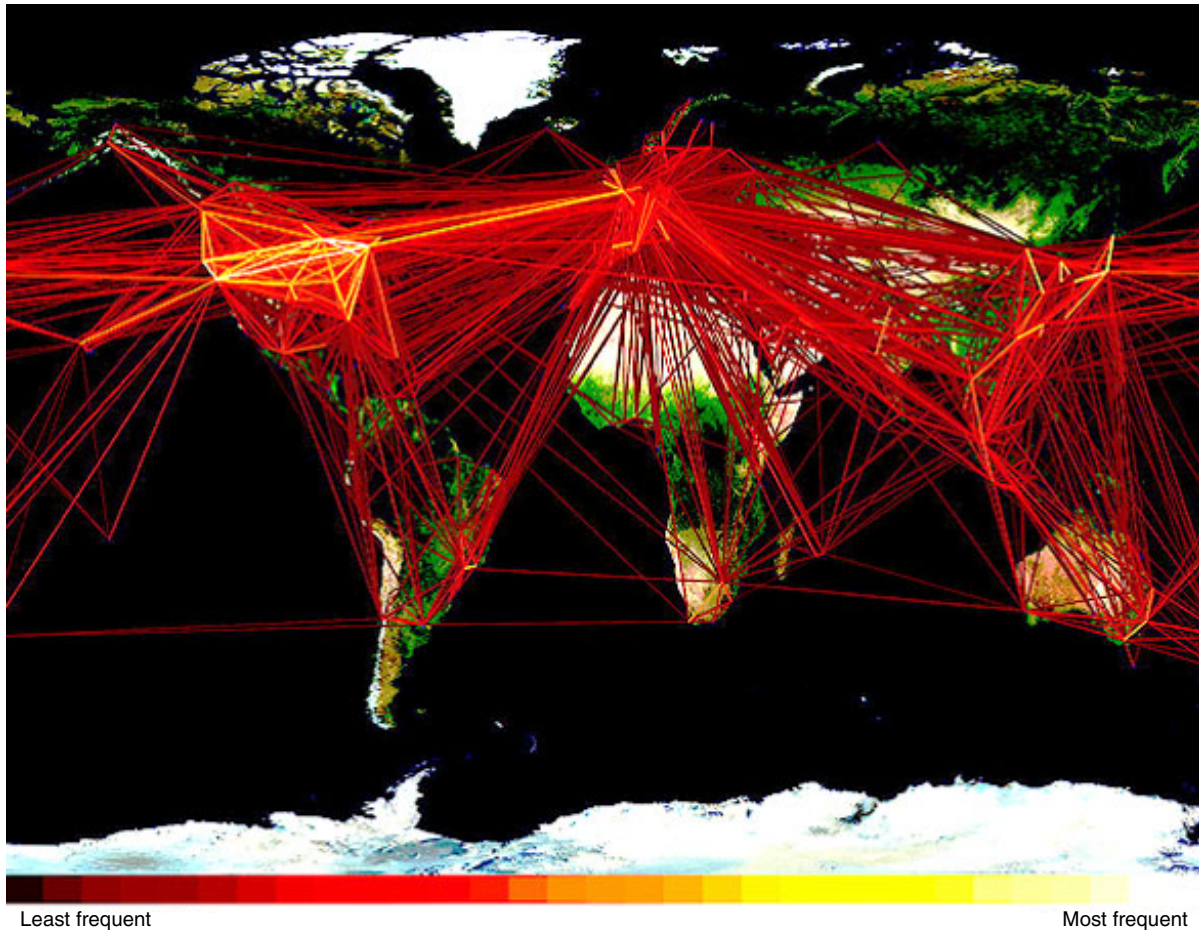


Figure 1. Global aviation routes⁷ showing the proliferation of travel routes as mechanisms for the spread of infectious diseases. (Reproduced with permission from Ref. 7 © 2004, National Academy of Sciences, U.S.A.)

Table 1. Summary of the WHO International Health Regulations 2005.¹¹

Key Area	International Health Regulations 2005 Modification
Expanded Scope	Notification of any event that may constitute a public health emergency of international concern
Decision Instrument	Establishment of algorithm to assist in identification of public health events
Contact Points	Identify in-country contacts that are accessible at all times, thus enabling effective communication between WHO and member countries
Core Surveillance and Response Capacities	Develop, strengthen, and maintain capacities to detect and respond to public health emergencies of national concern
WHO Support	WHO is required to assist member countries in fulfilling the new International Health Regulations obligations

by which epidemiologists monitor the health of their community on a daily basis.¹² It is with this thinking in mind that we are suggesting the implementation of similar electronic disease surveillance capabilities—although appropriately scaled based on resources, personnel, and threat—in resource-limited settings. Although the fear of a covert biological attack in these communities is not high, of greater concern are emerging infectious diseases that could have ill effects on the local country’s population and economy and have the potential to escalate to a global scale.

Recognizing that much work is being done in the investigation and implementation of particular technical components that could serve as functional pieces of a surveillance

system, the focus of our efforts is on the systems-level end-to-end implementation of an electronic disease surveillance network. Such a network would be composed of tools for data collection, a data repository, analytical capabilities for detection of unusual events, and the ability to view and transmit data to others for review or further compilation. There have been numerous studies that have shown success in a specific piece of the larger proposed system. For example, research has shown the benefit of providing remote health workers with handheld-based decision-support tools to assist in prenatal care and child health in India.¹³ Additionally, one study in a rural Kenyan health center reported on the value of establishing a database of patient information.¹⁴

Both instances illustrate how technology provided information that was not previously available. In the case of the handheld units, the health care workers were able to access the latest available information, which increased their knowledge and helped improve the delivery of care to their patients. Likewise, in Kenya, the health center was able to use previously unavailable information to monitor their population. These “successes” underscore the benefit of technology utilization, and, therefore, the hope is to couple these types of tools with a larger system approach to improve the overall level of surveillance in a resource-limited country.

INTERNATIONAL SITE VISITS

As part of the evaluation task undertaken by the APL and DoD-GEIS team, site visits were conducted in resource-limited countries currently using some form of electronic disease surveillance system. These visits were initiated to better define the types of questions that must be considered as systems-level requirements during system implementation. Site visits enabled first-hand knowledge of the system setting and provided the invaluable experience of speaking with system implementers and end users to understand and to assess what is working versus what could potentially be improved with respect to data collection, transmission, analysis, and interpretation (Fig. 2).

The initial site visits were conducted in Lao People's Democratic Republic, or Laos for short, in September 2006 and in Peru in March 2007.

In both settings, the Early Warning Outbreak Recognition System (EWORS) had been developed and deployed by the Naval Medical Research Unit 2 and the U.S. Naval Medical Research Center Detachment (NMRCDD) in conjunction with the host countries (Fig. 3). In addition to EWORS, the Peruvian Navy and NMRCDD also implemented Alerta DISAMAR, a system that uses commercial technology to integrate surveillance data across diverse communications platforms.¹⁵

Based on the experiences gained through these site visits, the evaluation team drafted a generalized



Figure 2. Dr. Howard Burkom of APL reviews the EWORS system with Dr. Khanthong Bounlu, Chief of the Laboratory of Serology and Virology at the Center for National Laboratory and Epidemiology in Lao People's Democratic Republic.

framework for when an electronic disease surveillance system is being considered in a resource-poor setting (Table 2).¹⁶ Although Table 2 illustrates the overarching key concerns that need to be addressed at the highest levels of the public health organization, the following discussion focuses primarily on the technical considerations: data collection and transmission, analytical capability, and training.

DATA COLLECTION AND TRANSMISSION

Assess the Public Health Structure

It is critical to perform an initial assessment of the country's public health infrastructure with the goal of gaining a better understanding of the Ministry of Health's (MoH) organizational structure, determining what, if any, surveillance practices currently exist and ascertaining how data currently are being collected, transmitted, and analyzed within the country. The review of the MoH organizational structure will assist in determining how data currently flow throughout the public health community. For example, in a decentralized system, the local public health authorities are responsible for responding to outbreaks within their jurisdictions, but they do report aggregated data up to the national level on a periodic basis.¹⁷ Findings from this assessment can assist in determining the conceptual value added of establishing an electronic disease surveillance system within the existing health system infrastructure.

Many times, developing countries or localities already have surveillance activities in place for conditions such as influenza-like illness (ILI) or dengue. So there quite possibly already may be ongoing efforts to conduct surveillance in hospitals, in private physician's offices, in

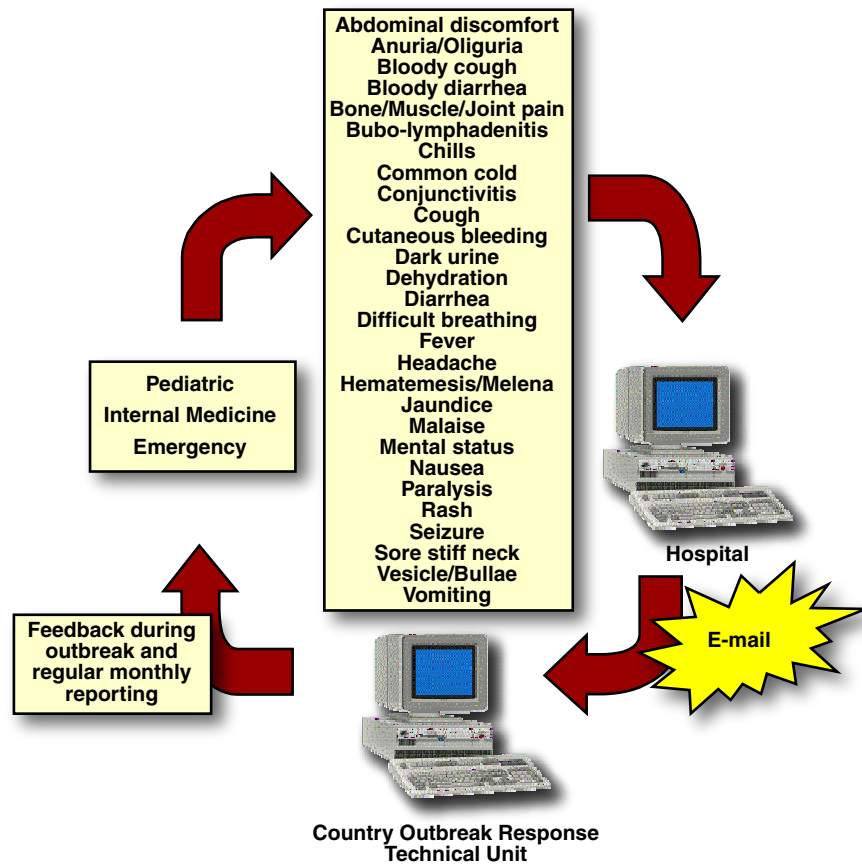


Figure 3. Diagram of EWORS¹⁵ as currently used in Lao People’s Democratic Republic. (Adapted with permission from Ref. 15 © 2007, John Wiley & Sons, Inc.)

Table 2. Key considerations in planning electronic syndromic surveillance systems in low-resource settings.¹⁶

Technical	<ul style="list-style-type: none"> • Use existing data feeds, when possible • Automated decision support may facilitate timely data transmission • Training is essential • Technical partnerships can facilitate implementation
Financial	<ul style="list-style-type: none"> • Use best-fitting, low-cost data collection methodology/technology for the locale • Open-source-based/customized software preferred • Partner, where possible, to share technology needs
Political	<ul style="list-style-type: none"> • Competition for limited health resources may exist • Local political support is essential in decentralized MoHs • Engage key stakeholders to ensure that there are no conflicting priorities • Systems must be locally supported and not sponsor-driven
Ethical, Societal, and Cultural	<ul style="list-style-type: none"> • Privacy safeguards may address patient concerns of data capture • Education may improve patient acceptability of surveillance • Education on diseases may enhance both detection and patient care • Health-seeking behavior may limit system effectiveness

laboratories, or within the community. Knowledge of these systems may be beneficial in the data collection and transmission aspects of a more encompassing electronic surveillance network. Existing surveillance efforts provide reassurance that some level of data collection and transmission already is occurring and that the concept and practice are accepted, at least in theory.

Define System Purpose and Requirements

After an initial assessment of the current practices of the MoH and the associated public health community are understood, the first step is defining the purpose of the system and developing the system requirements. The key considerations for the purpose and requirements include

- What diseases are of most importance?
- Why is surveillance being conducted?
- What are the current laboratory capabilities?
- What is the realistic expectation with respect to data collection?
- How much data should be collected?
- How frequently will data be analyzed?
- Will routine training be available?

These questions cover a range of activities relating to electronic disease surveillance systems, from conception through long-term sustainability, and the answers will differ depending on who, within the community, is asked. For example, the local community may be greatly concerned about dengue fever surveillance, whereas at a national level they are more concerned with ILI, which may signal a larger global public health threat. Asking the appropriate questions and considering the operating environment before choosing a system will help ensure that goals are not unrealistic given the constraints that may be present.

Data Availability and Selection

Once the system requirements have been identified, the next step would be to identify what data should be fed into the electronic surveillance system. For the purposes of this discussion, data are defined as any information that would be of value in an electronic surveillance system. It could be patient-level data gathered from health clinics, laboratory test requests or results, etc. Regardless of whether a surveillance system is in a developed country or a resource-poor setting, implementers should not want to include data just because it is readily available. For example, if a surveillance system is aiming to capture a rural population, it will not be an effective use of resources to obtain pharmacy data from an urban area even though it may be readily available. Data sources must be assessed for a number of key factors, such as the lowest reasonable level data, identification of the data to be collected, method of data collection,

and method of data transmission. Knowing what data already are being collected electronically, and with what frequency and reliability, for example, will be imperative in any discussions surrounding electronic disease surveillance systems.

From a technical standpoint, it always is best to use existing data feeds when possible. Even in the developed world it is much easier from a time, cost, and relationship-building standpoint to use existing data streams,¹⁸ which means that the feeds have been established, saving potentially a lot of time and money. Additionally, where possible, it is beneficial to leverage technical partnerships to facilitate implementation.

Data Entry and Transmission

Data entry and transmission are key components to any electronic disease surveillance system. Without sufficient quantities of reliable data, a system will not be able to operate successfully, regardless of the environment, whether developed or resource-limited. Considerations for data collection in a resource-limited setting include

- What is the lowest level at which data will be collected?
- What data will be collected?
- By what method will the data be collected?
- How will data be transmitted to others?

Key to this discussion of data entry is how data will be captured at the lowest level and reliably transmitted to the next level. Although that topic is detailed and outside the scope of this article, it has been shown that laptops, personal digital assistants (PDAs), and phone lines all have proven to be viable options.^{15,19} Transmission issues can be addressed with a variety of tools, including the Internet, universal serial bus (USB) drives, PC cards, satellite phones, and interactive voice-response systems.¹⁶

ANALYTICAL CAPABILITY

Once the system requirements and data needs have been identified, the next step will be to determine what analytical capability will be required in the system. Many MoHs in developing countries use open-source analytical packages that are capable of trend analysis. Although this software is invaluable for understanding what is normal for a community, it will not meet the newly established need of enhanced surveillance for the purposes of early event detection. In some instances, it may be necessary only to enhance the existing tools by adding an early event detection component. In other instances, there may not be any existing software in place. Although this situation allows for greater flexibility, the implementers should weigh the use of a more appropriate open-source package, if available, to ensure affordability and long-term sustainability. Like-

wise, developing custom software is a viable option to ensure complete functionality if existing packages will not meet the system requirements. In total, potential implementers and users have expressed concerns over using commercial technology because of lack of ownership. Additionally, introduction of software may have expensive recurring costs, and future software upgrades may be costly in terms of training and resources (results of the breakout session, *Disease Surveillance Workshop*, Bangkok, Thailand, 12 September 2007). The overarching issues of configuration management and software maintenance are a huge factor in systems engineering.

TRAINING

Training end users on how to use an electronic disease surveillance system is a key component to making a system functional. This training will vary by country and level of government, but the process may include an education of basic epidemiology in addition to system use. System use includes not only a basic understanding of how data are sent and processed by the system but also how to interpret “flags” that may be generated by using the early event detection capability.

A sophisticated system with an unskilled user is not valuable; similarly, a basic system in the hands of a trained end user can be an extremely valuable resource. That said, thought must be given early on in the development stages as to how training will be delivered to the end users and what kind of ongoing support will be available to account for the staff attrition that may be seen in the local public health community. Given that the areas in which the systems will be deployed have limited resources, the implementers must have an effective training strategy in place that addresses the questions of both initial training as well as training for any upgrades and functionality in the future.

In many countries, where decentralized models prevail, financing ongoing maintenance and training activities is likely to fall on the local levels. Although support for the development and implementation of an electronic disease surveillance system may be present at the outset, there always is the chance that priorities will shift in light of changes in the political landscape, perceived threats, and reallocation of resources. These challenges are not insurmountable; implementers can build robust, though simplistic, systems that will not require lengthy, ongoing training.

CONCLUSIONS

Despite the many challenges that seem to exist when considering the implementation of an electronic disease surveillance system, the end result has great potential to become a beneficial tool for both early event detection as well as routine monitoring of a community's health.

To develop and deploy an effective end-to-end system, much thought and consideration must be given early in the process to ensure an efficient use of resources in the long run. We have highlighted many of the key considerations while focusing on the technical components of the system in the hope of assisting countries in their efforts to enhance their surveillance capabilities in light of the WHO International Health Regulations 2005.

STATUS

Based on our work to date, the working group was invited by the U.S. Armed Forces Research Institute of Medical Sciences to visit the Philippines and assess their ability to deploy an electronic disease surveillance system. The country recently drafted policy titled “The Philippine Integrated Disease Surveillance and Response (PIDSUR),” which calls for improvement in their surveillance efforts. APL and DoD-GEIS are in the early stages of developing a pilot electronic surveillance application for deployment in one region of the country.

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