Global Health Surveillance—Guest Editor's Introduction

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Improving the overall health of a given population has far-reaching effects not only on the economy and stability of that particular population but also on a global scale. Disease surveillance, a critical component in understanding and improving global health, is undergoing a revolution driven by advances in information technology. Recent years have seen vast improvements in the collection, analysis, visualization, and reporting of public health data. At the Johns Hopkins University Applied Physics Laboratory (APL), teams of software engineers, analysts, and epidemiologists have been working for more than 15 years to develop advanced electronic disease surveillance technologies. This issue of the Johns Hopkins APL Technical Digest *describes the development and implementation of these technologies, the process and challenges of making the tools open source, and potential new analytic models for early detection of disease outbreak.*

INTRODUCTION

People are particularly fearful of a pandemic caused by the global spread of a novel naturally occurring disease such as Middle East respiratory syndrome coronavirus or a pandemic influenza A strain. This fear is understandable given that novel diseases represent the unknown: How quickly and easily does the disease spread from person to person? Who is most susceptible to the disease? What is the likelihood that I or my family will die from the disease if we contract it? These fears are not unfounded, as infectious diseases know no geographic boundaries, and globalization has connected people and parts of the world today more than in any other time in our history. Social and mainstream media can amplify these fears. Many of us have the ability to search the Internet to find more information on a new disease than we can possibly comprehend and to see the ample chatter on social media sites.

Fortunately, the World Health Organization (WHO) sets requirements for member countries to report certain diseases. Before the severe acute respiratory syndrome

(SARS) outbreak in 2003, the WHO International Health Regulations (IHR) required member countries to report only outbreaks of cholera, yellow fever, and plague. However, as witnessed during the SARS outbreak, a disease that was first identified in China and Hong Kong quickly spread to the United States and Canada, and the existing IHR did not adequately address the growing threat of emerging diseases in a globalized world. Not only did health authorities have to deal with challenging decisions related to slowing the spread of disease (such as by closing certain venues), but few jurisdictions had a way to easily assess the health of their populations. As a result, in 2005, the WHO adopted new IHR. These new IHR, commonly referenced as IHR 2005, require member countries to report any disease that may constitute a public health emergency of international concern. Additionally, the IHR stipulate, albeit at a high level, that countries will improve their capacity to detect, assess, communicate, and respond to public health threats. These new IHR 2005 went into effect in 2012, but to date many countries are still having difficulties complying.

Furthermore, in February 2014, numerous countries, including the United States, committed to the Global Health Security Agenda (GHSA), whose goal is to accelerate progress in the prevention of, detection of, and response to infectious disease threats over a five-year period. The GHSA specifically targets infectious diseases and includes the topics of novel disease propagation and globalization of trade and travel, in addition to highlighting concerns about increasing antimicrobial drug resistance as well as the threat of disease from the accidental release, theft, or illicit use of a disease agent.

The latter point—accidental release, theft, or illicit use of a disease agent—also draws attention to the growing field of "do-it-yourself (DIY) biology" as well as to research ethics. DIY biology, while often well intentioned and practiced as an after-hours hobby by many trained researchers in academia and corporations, is an unregulated or self-regulated activity. Some in the scientific community fear this DIY work could result in inadvertent or malicious development and release of a biological weapon, heightening the need for increased surveillance capacity.

Also of concern is the ability of scientists to replicate diseases in such a way that modifies their lethality. Although it is truly awe inspiring that science has come so far, charged discussions result when researchers want to share their findings worldwide by publishing their results in peer-reviewed scientific publications, which is the norm for those working in the field. In recent years there has been debate over the ethics of publishing research that exposes the "recipes" for replicating viruses and changing the virulence of viruses such as avian influenza (H5N1). Many fear that such publications could provide those with nefarious intent with the information needed to develop a "superbug." As scientists continue to make advances in the rapid identification and experimentation of novel pathogens, this debate will likely continue for years at the highest levels of government and academia.

The scenarios described above underscore the importance of the global health surveillance program at the Johns Hopkins University Applied Physics Laboratory (APL). The program operates within the space of predicting, detecting, and responding to infectious disease within the human population, both domestically and internationally. That being said, effective electronic disease surveillance systems represent just one part of a much larger effort to protect the global population against the threat of emerging and re-emerging infectious diseases. APL's role in this domain is to combine public health expertise with information technology (IT) and analytics to achieve effective and sustainable solutions for public health officials worldwide.

At APL, teams of software engineers, analysts, and epidemiologists have been working for more than 15 years to develop advanced electronic disease surveillance technologies. As has been discussed in previous issues of the *Johns Hopkins APL Technical Digest*, public health entities the world over have lacked the benefit of IT solutions until as recently as 10 years ago. Today in the United States, public health professionals in most states have the capability to collect, analyze, and visualize data to assess the health of their communities. Additionally, there are public health "super users" who are taking electronic disease surveillance to the next level and using the data to investigate many types of public health issues such as chronic disease, injury, and mental health. However, in many places around the world, and particularly in resource-limited environments, public health officials are on the front line of defense against the next epidemic—without the benefit of state-of-the-art electronic disease surveillance capabilities.

THE ARTICLES

In this issue of the *Digest*, we highlight the ever-increasing role APL is playing in the area of global health surveillance.

The first article, by Feighner et al., highlights the Suite for Automated Global Electronic bioSurveillance (SAGES), the cornerstone of the current global health surveillance program that builds on the successful Electronic Surveillance System for the Early Notification of Community-based Epidemics (ESSENCE) program. This article describes not only the technology being used to build the capacity of U.S. partner countries but also the process by which APL works with its long-term sponsor, the Global Emerging Infections Surveillance and Response System, a division of the U.S. Armed Forces Health Surveillance Center (AFHSC-GEIS). AFHSC-GEIS is committed to improving infectious disease surveillance worldwide for all DoD health care beneficiaries as well as for the global community. In this role it is guided by four goals: (*i*) conduct surveillance and outbreak response activities, (*ii*) improve the capacity of partner countries to perform disease surveillance, (*iii*) support research initiatives that will result in new capabilities in support of force health protection, and (*iv*) assess and communicate through its worldwide network.

The main analysis and visualization tool within the SAGES tool kit is OpenESSENCE (OE), an open-source version of the ESSENCE system. OE combines advanced analytics with a flexible platform to collect and visualize data that vary greatly in both volume and granularity. First, Campbell et al. highlight the OE features and functionality that public health users have deemed critical for interpreting health data at both the individual and aggregate levels. Burkom et al. then describe the analytics used in the OE platform and the work that went into refining them for partner countries whose data may differ vastly from those collected in countries such as the United States. The analytics enable early event detection and signal statistical anomalies that warrant further epidemiological evaluation without causing alerting fatigue to the public health monitors.

Data collection remains a challenge in resource-limited environments that may lack robust Internet capabilities or IT infrastructure. As a result, the SAGES tool kit includes technologies to enable data collection via cell phones. Poku and Katz describe the use of mobile technology in the SAGES platform and the larger movement in the mobile health, also known as mHealth, community.

Technology development is just one piece of the solution. Many of the complexities of disease surveillance involve implementation of the software with the partner countries. Just as in the U.S. public health system, the skill of the public health and IT workforce varies from site to site, and as a result, the technology implementation strategy must be adaptable and flexible to maximize the likelihood of success. Shraddha Patel describes the SAGES implementation process used by the APL and sponsor team.

Another element of the overall solution is making the tools available to the widest array of users who will not only use the tools but also improve them. To meet this need, the U.S. government is increasingly adopting the use of open-source products. By definition, *open-source software* refers to software products whose code is available for use and/or modification by anyone. Although this concept allows for greater flexibility and collaboration, it is not without challenges. Erin Hahn describes the drive behind open-source software, particularly in the health community, and the decisions developers and the sponsor community must consider. Open-source software is often desirable in resource-limited settings because it lacks licensing fees. Other desirable features of open-source software are the ability for users to add to the code base and its transparency, which reassures adopters that their data are not being released unknowingly to third parties. Raj Ashar describes the issues the sponsor and APL team encountered during the open-source release process for the SAGES software tools.

As was mentioned previously, social media is an increasingly popular mode of communication. It is one that holds great promise for the early detection of infectious disease. However, before data derived from social media can be effectively used in disease surveillance systems, work is needed to understand whether and how these data are correlated with more traditional health data. Coberly et al. describe a study in which they looked at Twitter data in the Philippines and correlated them with data gathered by a partner country.

Just as Coberly et al. are looking for ways to enhance current surveillance capabilities, the adaptability of a flexible analysis and visualization engine such as OE enhances public health professionals' capabilities. Campbell et al. describe how they have applied the OE framework for the AFHSC-GEIS respiratory disease surveillance network. Although partner countries currently use OE to monitor for infectious disease outbreaks, the respiratory dashboard, developed on the same framework, is being used as a tool to upload respiratory diagnostic test data across the AFHSC-GEIS partner network to provide a global picture of respiratory disease.

Again looking to advance the tools and capabilities, in the final article of this issue Buczak et al. describe their work to improve public health monitors' ability to detect a potential disease outbreak before it becomes a reality. The hope is that monitors will use these novel prediction methodologies in conjunction with electronic disease surveillance tools, thereby alerting health officials to more closely monitor for a potential disease risk and to take mitigating steps before a disease outbreak occurs.

Finally, Loschen et al. discuss the work done to date to use the cloud environment to host ESSENCE here in the United States. While cloud computing is not currently a viable solution in austere environments, it holds great potential for the future given how rapidly IT capacity is increasing worldwide.

FINAL THOUGHTS

Nations have long used health as a diplomatic tool. Improving the overall health of a given population has far-reaching effects on the economy and stability of a population, whether it is as small as a village or as large as an entire country. Indeed, improving the health of one population has effects on populations worldwide. Through the efforts of many U.S. government agencies, some of which have been tackling this problem long before the GHSA, in concert with partner countries and international organizations, the face of global health diplomacy is slowly changing. The U.S. government, now more than ever, is strongly committed to global health diplomacy as a means to improve not only health but also global economic and political stability. It believes, as do members of the APL team, that a "public health emergency anywhere is a public health emergency everywhere."

The Author

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