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Transforming Public Health Systems to Meet Today’s Health Threats
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Introduction
Public health is not a new field. Every successful civilization has recognized the health implications of clean water and the efficient disposal of human waste. Dr. John Snow is credited with ushering in the modern age of public health when he identified a polluted well in the slums of London as being the principal source of the 1854 cholera outbreak. Today, the public health agenda has been defined and driven by national and international agencies such as the World Health Organization, the National Health Service (NHS), the Centers for Disease Control and Prevention, and the Institut National de Veille Sanitaires.

The public health challenge facing communities and governments has never been greater. Tourism, economic migrancy, and a global business market result in large numbers of people traveling internationally, often through major hubs such as Singapore, Hong Kong, and Dubai, but also surreptitiously through porous borders. For these reasons, epidemics and pandemics may pose immediate and acute threats to a nation’s health system, economy, and political stability.

The recent emergence of new strains of influenza and the rapid rate of dispersion of these infectious agents around the globe has demonstrated how exposed the security of nations is to these invisible threats. No government can afford to ignore the possibility of a repeat of the 1918 influenza pandemic in which an estimated 50 million people died. And today’s mobile society may be primed for an even more disastrous pandemic. Thanks to a global 24-hour news system desperate to fill air time, news of outbreaks travels fast, and citizens themselves increasingly demand that governments protect them from these frightening health threats. This intense scrutiny is increasingly exposing gaps in public health systems worldwide.
This white paper focuses on the challenges for policy makers seeking to transform outdated, inadequate public health surveillance systems, and the opportunities for leveraging newly emerging technologies that will make this transformation possible.
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Defining Disease Surveillance for the Twenty-First Century

Active Versus Passive Disease Surveillance Systems

Disease surveillance is based on counting. Cases of disease are counted; the dimensions of who, what, where, when, how, and why form the cornerstone for the training of every epidemiologist. This case-counting process may be active or passive. Passive disease surveillance remains today the predominant way that case information is reported to public health officials. The quality of this passive method of reporting depends on the actions of physicians, hospitals, and laboratories to identify and promptly report a case of notifiable disease or a positive laboratory result that suggests the presence of a notifiable disease. Laws, regulations, and ordinances dictate which diseases are notifiable to public health agencies, the method of submitting these reports, and the information required in the report. These laws, regulations, and ordinances vary over time and among cities, regions, states, and countries. Compliance with these reporting requirements also varies, but is frequently inadequate to meet the disease surveillance requirements facing today’s public health leaders. This is because the current, paper-based passive reporting systems rely on a person (physician, nurse, administrator, laboratory technician, and so on) to submit the reports to public health officials. Unfortunately, public health reporting is too often delayed, incomplete, or even forgotten because of the competing priorities facing today’s healthcare workforce.

Active surveillance differs from passive surveillance by the methods used to identify new cases. Unlike passive surveillance, active surveillance relies on the overt efforts of public health officials to proactively identify and report cases of disease. Usually this involves assigning public health staff to hospitals or clinics to review medical charts to identify new cases. Unlike passive surveillance systems, active surveillance reporting is typically timely, complete, and inclusive. With few exceptions, however, public health agencies lack the resources to conduct widespread, comprehensive active disease surveillance.

New technologies today offer the promise of transforming passive surveillance systems from ones that burden the healthcare providers and are inadequate for today’s disease surveillance requirements into systems that perform equally well or better than labor-intensive, costly active
surveillance systems. This transformation is based on automation of data collection, data analysis, and data reporting, as seen in

- The emergence of electronic health record systems, hospital information systems, and laboratory information systems that capture the information required for electronic public health case reporting
- New software tools that can integrate and analyze these disparate datasources using sophisticated rules and algorithms designed specifically for extracting public health case reports
- Tools that transform the multiple data coding and formats commonly seen in these source data systems into a standard electronic format that is then securely transmitted to appropriate public health agencies

Figure 1 illustrates the role that automation plays in transforming passive surveillances systems into systems that have the reporting attributes of active systems without the excessive costs associated with these systems.

![Figure 1. The impact of automation on passive surveillance systems](image-url)
Sensitivity Versus Specificity of Disease Surveillance Systems

Sensitivity and specificity are two traditional attributes used to evaluate disease surveillance systems. A sensitive disease surveillance system is one that rapidly identifies all cases and all potential cases of a disease.

Surveillance systems with high specificity, by comparison, are ones that correctly and uniquely identify cases of disease under surveillance. There are no false-positive or duplicate case reports in highly specific disease surveillance systems. The speed of reporting and completeness of reporting of these cases often are not attributes of surveillance systems with high specificity.

Disease surveillance based on traditional passive case reporting is often highly specific but lacks sensitivity. Analysis of these data may provide a useful estimate of the burden of a disease in a population over time, but are usually poor predictors of current disease trends, especially when trend changes occur rapidly. The 2009 global H1N1 influenza pandemic has clearly illustrated the gaps caused by traditional passive surveillance systems, as health authorities struggle to rapidly identify cases so that prevention measures can be implemented in time to reduce the impact of disease in the community. There are two fundamental causes of this problem in traditional disease surveillance sensitivity: delays in reporting and failure to report all cases.

New technologies, however, offer the possibility that surveillance system automation will transform data collection, data analysis, and data reporting resulting in dramatic increases in surveillance system sensitivity and specificity. This automation will increase system sensitivity by rapidly identifying all potential cases that are entered into an electronic medical records system and then securely transmitting these cases to the appropriate public health agency. Specificity increases with the adoption of person-matching and database analysis software tools that prevent duplication and false-positive reports. Figure 2 illustrates the impact of automation on surveillance system sensitivity and specificity.
Comparing Traditional and New Situational Awareness Systems

Since 2001, increasing efforts have been devoted to addressing shortcomings in traditional disease surveillance system sensitivity. The initial driver for this new focus was the threat of bioterrorism. Today, this effort now fully embraces both traditional and new, emerging public health threats from any source.

Biosurveillance is the label initially applied to this more-agile, sensitive approach to disease surveillance. The original goal proposed for biosurveillance was narrow; its purpose was to identify terrorist health threats at the earliest possible time, ideally before infection or transmission occurred in a community. Today, a broader set of goals is applied to this type of disease surveillance. Situational awareness is the term more commonly and correctly used today.

When available, health officials and government leaders now rely on situational awareness systems to better understand: when a public health threat is growing or decreasing; whether it is expanding into different geographic areas; and whether the threat is becoming more or less serious to the community or population. This knowledge influences decisions ranging from the deployment of additional or specialized resources to respond to the threat; to implementing plans...
to provide mass vaccinations or treatments; and to decisions that affect the movement of people within a community (for example, school closings, canceling public events, or closing borders).

The hallmarks of situational awareness systems are the use of new, novel sources of data that are combined to increase system sensitivity. The contribution of these datasources often varies among jurisdictions. In the U.S. these datasources include

- Hospital emergency room chief complaint codes
- Hospital laboratory tests that have been ordered by the clinician
- Hospital laboratory tests results
- Hospital discharge diagnosis codes
- Hospital admission numbers
- Hospital discharge numbers
- Hospital deaths numbers
- Community pharmacy inventory and sales data
- School absenteeism rates

Other countries have identified new datasources that will contribute to increasing the sensitivity of their situational awareness systems. One example of such a new datasource can be seen in automated patient call centers that employ complex rules for rapidly and accurately triaging patients based on criteria that are locally established and that can be quickly modified as outbreak characteristics change.

These disparate datasources are securely transmitted, using standardized vocabulary and message structures, to both state and national analysts in near real time. Highly sophisticated, rapidly evolving temporal and spatial software algorithms have been developed to enhance the sensitivity of these data to identify new or emerging threats to the public health and to rapidly identify changes in existing outbreaks or epidemics.

Situational awareness systems are a complement to traditional disease surveillance systems. Their power lies in their ability to quickly identify potential new health threats, or to closely track changes in the characteristics of an existing outbreak or epidemic. But situational awareness systems alone are not designed to uniquely identify a specific public health threat or the individuals that are affected. For example, these systems might identify changes in consumer purchases of off-the-shelf medications for cold or influenza, rapid increases in the number of people who go to hospital emergency departments because of respiratory distress, or unusual spikes in laboratory tests that have been ordered in hospital emergency departments for influenza.
The goal for public health disease surveillance in the twenty-first century will be to establish and enhance both traditional and situational awareness disease surveillance systems. This will be accomplished in three ways.

- First, automated electronic case and laboratory result reporting will significantly improve the sensitivity of traditional disease surveillance systems and are important datasources for situational awareness systems.

- Second, the barriers to disease surveillance system interoperability within public health agencies must be reduced or eliminated. (This is discussed in the next section.)

- Finally, public health agencies working with new, nontraditional partners (for example, pharmacy sales inventory systems) will establish automated datasources for situational awareness systems. Sophisticated surveillance systems capable of efficiently consuming massively large data sets and applying complex statistical analyses to identify anomalies must be implemented. Emerging as an important component in analyzing these disparate datasources are medical and public health ontology tools that are capable of interpreting relationships between dissimilar datasources not otherwise recognized. Together, enhanced traditional and situational awareness surveillances systems will provide public health and government leaders the tools they need to rapidly and accurately identify and respond to twenty-first century public health threats.

Health Department Surveillance Systems: From Silos to Data Integration

Discussions so far presented have focused on new and exciting opportunities to transform public health and disease surveillance systems from the perspective of the physician or hospital (in other words, disease surveillance datasources). With advances in specialized software that query electronic medical records and laboratory information systems to automatically identify public health reportable conditions, it is now possible to deliver improvements to disease surveillance systems that could not be previously imagined. Epidemiologists and other health department officials can now look forward to the time when timely and complete case and laboratory result reporting is routine.

However, improving the timeliness and completeness of data access solves only half of the challenges facing public health today because most public health departments are today organized vertically into data silos. Too often, these silo public health programs are disconnected for diseases or conditions like HIV/AIDS, tuberculosis (TB), H1N1 influenza, and sexually transmitted diseases (STDs). In today’s world, where news media and the public expect almost immediate information on emerging public health events, this dysfunctional model of disease surveillance system communication (system interoperability) is unacceptable.

Public health officials recognize that this type of vertical organization hinders the ability of epidemiologists to fully assess the impact of diseases and conditions that affect the public health. For example, risks for TB are often similar to other conditions like HIV/AIDS, STDs,
alcoholism, hepatitis, smoking, diabetes, asthma, and heart disease. However, the multiple public health surveillance systems that track these diseases and conditions are rarely capable of the types of data analysis needed to understand these complex multidimensional problems. In short, these systems “can’t talk to each other”—a refrain all too often heard in public health agencies worldwide. For these reasons, a number of health departments and health ministries are pursuing integrated, standards-based, public health surveillance system solutions that seamlessly incorporate disparate data silos from across a healthcare landscape. New informatics solutions are emerging that reduce or eliminate these challenges by establishing effective silo system interoperability. These new tools provide ways to retain many of the data silo systems while establishing interoperability across multiple disease-specific surveillance systems using specialized software that can handle multiple data coding formats. A critical component of these new tools is a master person index that is used to link individuals across many disconnected data silo systems. Only by eliminating the barriers to data integration among multiple health department data silos can a country achieve the goals for a twenty-first century disease surveillance system.

Data Analysis

Tremendous progress has been made in the practice of data analysis and data visualization. New software tools that can apply sophisticated spatial and temporal analysis are now available. Medical and public health ontologies are becoming more sophisticated and are now revealing complex relationships not previously seen between individuals, diseases, the environment, and virtually any other components associated with a patient, disease, or an outbreak. Advances in geographic information systems now provide health officials with unprecedented data visualization abilities. All of these powerful data analysis and visualization tools, however, are dependent on the structure and performance of the data systems in which the data are stored, and the training and support provided to the public health data analysts.

Health Information Exchanges

The importance and value in sharing healthcare data are becoming more widely recognized. In many countries health information exchanges (HIEs) are forming. These may be driven by financial incentives, by efforts to improve healthcare, or by governmental requirements. They are usually configured to meet the needs of the participating communities by connecting disparate healthcare entities. While challenges may exist in establishing HIEs, they are showing promise in their ability to improve patient care and reduce costs by providing access to a wider array of physicians, hospitals, laboratories, and public health agencies. Work is underway in some countries to connect multiple HIEs together to form a national health information network. This model supports expansion to other jurisdictions and to other partners as they become available. Increasingly, HIEs are serving as new, important datasources for public health disease surveillance systems.
Beyond Disease Surveillance: Additional Automation Opportunities

While this white paper has focused on ways to transform disease surveillance, the increasing adoption rate of electronic health record systems also offers new ways for improving other monitoring and reporting systems. Some examples of these uses include

- Automatic updates to birth and death registry systems
- Immunization and cancer registry system data exchange
- Identifying people who may have healthcare associated infections, a rapidly-growing priority area that focuses on improving the quality of care provided by healthcare institutions and their staff
- Identifying patients who should receive preventive follow-up for chronic diseases
- Monitoring hospital unit census levels
- Identifying clinical and drug trial candidates
A Road Map for Transforming Public Health Surveillance Systems

Today’s political and public health leaders understand the threats posed by existing and newly emerging diseases to their citizens and to the economic health of their country. Now, more than ever, they recognize the need to reallocate scarce resources to reduce or eliminate these threats, but may be confused by the complexity of the challenges they face. While healthcare information technology is revolutionizing both clinical care and public health disease surveillance, every country will face unique problems as they work to improve these systems. In most cases, challenges exist at multiple levels. The following is a high-level road map of the strategies for accelerating the transformation of a country’s traditional disease surveillance system.

New, Automated Provider Data Systems Improve Traditional Disease Surveillance Sensitivity

Replacing manual, paper-based reporting systems with electronic systems offers unprecedented opportunity to transform inefficient public health disease surveillance systems to ones that meet today’s urgent needs for real-time, comprehensive awareness of health threats. The range of tasks associated with significantly improving access to disease surveillance data so that sensitivity of these systems can be increased include

- Establishing or expanding the deployment of electronic health record, hospital information, and laboratory information systems that support standards-based data exchange.
- At each location, deploying software that queries these electronic systems for cases of disease that are reportable to public health authorities. This specialized software must be able to import data in multiple formats, convert to standardized message and vocabulary formats, apply disease case reporting rules to identify potential cases, and securely transmit the cases to public health authorities.

Improving Public Health Agency Surveillance System Data Interoperability

Efforts are underway in many countries to significantly reduce the number of disease-specific data silo surveillance systems that are too often unable to exchange data. But, because the practice of public health surveillance is so broad and potentially changing, efforts that are directed to establishing interoperability between existing data silo surveillance systems will produce immediate, critically needed improvements. Tasks that will improve the interoperability of disease surveillance systems include

- Reducing the number of disease-specific data silo surveillance systems by building or purchasing multidisease surveillance systems that support standards-based exchange of data.
• Establishing interoperability between existing, disease-specific data silo surveillance systems using specialized software tools that are able to import, translate, and then export multiple data formats

• Creating personal identifiers to link existing disease-specific data silo surveillance systems using master person index (MPI) software tools

• Adopting analysis and visualization software tools that utilize a common person identifier to analyze and view data across all disease-specific data silo surveillance systems

• Adopting geographic information system software tools that support complex and innovative displays of health data

• Creating Web forms for manual data entry of critical disease surveillance data when electronic exchange of these data are not possible

Establishing a Situational Awareness System

Because of scarce resources and competing priorities, situational awareness systems may not be immediately feasible for many countries. However, when implemented, these systems can significantly enhance a country's ability to more rapidly identify new or changing threats to the health of its citizens. Tasks that will lead to establishing or improving situational awareness systems include

• Identifying new, novel datasources that will send real-time, secure data to appropriate public health authorities

• Establishing high-performance, scalable databases that can import these large data sets with no risk of system failure

• Developing or acquiring complex software data analysis tools that can rapidly shift through large, disconnected datasources to identify anomalies that may represent new or changing disease threats

• Establishing or enhancing communications protocols and technologies to alert other appropriate public health and government authorities to potential threats to the health of the citizens
Orion Health and Oracle Solutions: Targeting Public Health Systems Designed to Meet Today’s Health Threats

Orion Health and Oracle have a long history of collaboration on many healthcare-related projects. Each company contributes best-of-breed software tools that, together, combine to create solutions for the challenges facing today’s government and health leaders. The following is a high-level overview of the ways that Orion Health and Oracle address the major targeted areas (identified here) for transforming today’s public health surveillance systems.

New, Automated Provider Data Systems Improve Traditional Disease Surveillance Sensitivity

Product and Vendor Examples

- Electronic health record and laboratory information system vendors are rapidly developing or enhancing their applications to support standards-based data exchange. However, this is a complex and lengthy process that will probably be forever ongoing. Today, Orion Health’s Rhapsody Connect offers immediate solutions for the exchange of patient, clinical, laboratory, and pharmacy data between any trading partners, irrespective of their data messaging and vocabulary format requirements.

- Orion Health’s Rhapsody Connect has also been customized to include specialized case reporting rules that identify cases of disease that meet the criteria for public health reporting. Deployed at healthcare provider sites, Rhapsody Connect converts these data into a format that meets public health case reporting requirements, and then sends these reports—via a secure electronic message format—to the authorized public health agencies. This product, now being installed in dozens of hospitals and laboratories in the U.S., supports multiple public health data reporting formats for laboratory results, immunization registries, healthcare associated infections, biosurveillance, and hospital census/bed utilization. Sophisticated Oracle Database and data analytical tools are seamlessly integrated into Rhapsody Connect, providing data storage and analysis capacity that exceeds the system requirements wherever Rhapsody Connect may be installed.

Improving Public Health Agency Surveillance System Data Integration

Product and Vendor Examples

- In recent years, a small but growing number of vendors specializing in integrated disease surveillance public health systems have emerged. Some are focused exclusively on core infectious diseases; others adopt a more generalized approach to public health surveillance systems. Efforts are underway to develop or enhance these applications to support standards-
based data exchange. But, the same challenges associated with supporting emerging and changing data standards exist for vendors developing public health integrated disease surveillance systems. Orion Health’s Rhapsody Connect offers industry-leading data integration capability that supports any electronic data messaging or vocabulary format, easily converting electronic data into whatever format is required. Rhapsody Connect supports all existing data standards, and new, emerging standards are automatically included in regular product updates.

- Orion Health’s Concerto application is a portal that establishes interoperability between disease-specific data silo surveillance systems already deployed in public health agencies. The Concerto solution includes establishing linkages between multiple data silo surveillance systems using an electronic master person index. As with Rhapsody connect, Oracle Database and data analytical tools are seamlessly integrated into Concerto to provide the required data storage and analysis capacity. This combined Orion Health and Oracle solution establishes access to critical disease surveillance data across linked silo data systems not previously possible.

- The Concerto solution also uses Web form development tools to provide extensions to existing applications and the development of new interoperable applications. These are designed to meet current and future data entry requirements without the additional burden of developing disease-specific applications because they are developed within the Concerto centralized clinical data repository and master person index system.

Establishing a Situational Awareness System

Product and Vendor Examples

- Orion Health’s Rhapsody Connect has successfully established situational awareness data feeds from hospital and laboratory systems in many clinical facilities in the U.S. Additional community-based datasources further enhance the sensitivity of situational awareness systems. For example, Oracle’s Rapid Online Medical Advice solution uses Oracle Policy Automation. This may be deployed in a portal or in a call center, using clinical diagnosis rules that can be easily customized to meet local conditions. The solution generates questions to ask the patient, based on previous answers, and then allow a determination to be made about what the person has and what they should do. This is a potential situational awareness system datasource that can also help ensure that citizens receive the appropriate referral and treatment.

- Industry-leading, scalable database technologies that specialize in healthcare concepts, such as Oracle Healthcare Transaction Base, offer optimum performance for managing the massive and complex databases that typically constitute effective situational awareness systems. Paired with high-powered business intelligence tools offered by Oracle that provide innovative data analysis, visualization, and reporting functionality, this technology meets the challenges of analyzing today’s large and complex situational awareness system data.
• Oracle has developed specific capabilities in its database to improve situational awareness based on integrating very large data sets and applying sophisticated reasoning techniques. Data in any format can be captured into a semantic representation in Oracle. Then, based on this rule-based reasoning, the data are analyzed for hidden insights. This capability has already been proven in the area of situational awareness.

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C. Scott Danos, MPH, recently retired from the CDC after a 30-year career. Starting as a public health advisor, Mr. Danos was assigned by CDC to field epidemiology assignments in Los Angeles, CA; Washington DC; Indianapolis, IN; and New Orleans, LA. Upon reassignment to the Atlanta, GA, CDC headquarters, Mr. Danos codeveloped STD*MIS, a sexually transmitted disease surveillance system still utilized in most U.S. states. Later he joined, and then directed, the National Electronic Disease Surveillance System (NEDSS). Today Mr. Danos is the Orion Health Business Development Manager for Public Health.

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