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After reading this chapter you should know the answers to these questions:

- What are the three core functions of public health, and how do they help to shape the different foci of public health and medicine?
- What are the current and potential effects on public health informatics from a) the use of electronic health records and b) global disease outbreaks?
- What are the potential value and benefits for patients and clinicians to exchange data with public health agencies?
- What factors influence the use of immunization information systems (IIS) and how can this model apply to other areas of the health system?

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16.1 Introduction

Biomedical informatics includes health interventions at the population level. This chapter focuses on the public health system and specifically the role of governmental public health to improve the health of the entire population such as city, county, state or national level and how it relies upon an informatics infrastructure. Chapter 13 describes **health information infrastructure (HII)**, including its role in supporting public health.

Population-level informatics has its own special challenges and considerations. Creating information systems that inform health policy or support an understanding of the health of sub-populations usually requires a large number of cases and multiple data elements. Population health involves understanding the social determinants of health related to the environment, behavior, and socio-economic status.

Rapid increases in the number of data sources available to assess and understand aspects of health and determinants of disease in the population, improved analytical and visualization software like GIS, and the ability to integrate health data with other information makes public health

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informatics a foundational science for public health. Public health informatics can support primary prevention and disease interventions and public health research, while also informing public policy. However, much work remains to fully achieve the potential of systems that support healthier communities and populations.

16.1.1 Chapter Overview

This chapter primarily deals with the aspect of public health informatics that relates to the medical care of populations. The chapter will not discuss areas of public health like detecting threats to health from the food supply, water systems, unsafe roads or how informatics assists in human-caused or natural disaster management. Monitoring the environment for health risks due to biological, chemical, and radiation exposures (natural and human-made) has been of increased concern for protecting the public's health. Although they do not directly relate to medical care, such technologies are designed to protect human health and should properly be considered within the domain of public health informatics.

16.2 What Is Public Health?

Public health is a complex and varied discipline, encompassing a wide variety of specialty areas. The broad scope and diversity of activities make it difficult readily and concisely to define and explain public health. A common theme of all the activities is a primary focus on prevention.

One useful conceptualization defines public health in terms of its three core functions of assessment, policy development, and assurance (Institute of Medicine (IOM) 1988).

Assessment involves monitoring and tracking the health status of populations including identifying and controlling disease outbreaks and epidemics. By relating health status to a variety of demographic, geographic, environmental, and other factors, it is possible to develop and test hypotheses about the etiology, transmission, risk

factors and control options that contribute to health problems in a population.

Policy development is the second core function of public health. It utilizes the results of assessment activities and etiologic research in concert with local values and culture (as reflected via citizen input) to recommend interventions and public policies that improve health status. For example, the relationship between fatalities in automobile accidents and ejection of passengers from vehicles led to recommendations, and eventually laws mandating seat belt use. It is in the area of policy development that information technology may have its greatest impact.

Because public health is primarily a governmental activity, it depends upon and is informed by the consent of those governed. Policy development in public health is (or should be) based on science, but it is also derived from the values, beliefs, and opinions of the society it serves. Today, e-mail, Web sites, on-line discussion groups, and social media sites are the most heavily used Internet applications. Public health officials who wish to promote certain health behaviors, or to promulgate regulations concerning, say, fluoridated water or bicycle helmets, would do well to tap into the online marketplace of ideas—both to understand the opinions and beliefs of their citizenry, and (hopefully) to inform and influence them.

The third core function of public health is assurance, which refers to the duty of public health agencies to assure their constituents that services necessary to achieve agreed upon goals are available. Note that the services in question (including medical care) might be provided directly by the public health agency or by encouraging or requiring (through regulation) other public or private entities to deliver the services. For example, in some communities, local public health agencies provide a great deal of direct clinical care to underserved or at risk populations. The health department in Multnomah County, Oregon, for example, currently offers health care services in 7 primary care clinics, 3 county jails, 13 schools, 4 community sites and in people's homes. In other communities (e.g., Pierce County, Washington), local public health

Table 16.1 Ten essential services of public health (DHHS 1994)

1. Monitor the health status of individuals in the community to identify community health problems
2. Diagnose and investigate community health problems and community health hazards
3. Inform, educate, and empower the community with respect to health issues
4. Mobilize community partnerships in identifying and solving community health problems
5. Develop policies and plans that support individual and community efforts to improve health
6. Enforce laws and rules that protect the public health and ensure safety in accordance with those laws and rules
7. Link individuals who have a need for community and personal health services to appropriate community and private providers
8. Ensure a competent workforce for the provision of essential public health services
9. Research new insights and innovate solutions to community health problems
10. Evaluate the effectiveness, accessibility, and quality of personal and population-based health services in a community

agencies have sought to minimize or eliminate direct clinical care services, instead working with and relying on community partners to provide such care. Though there is great variation across jurisdictions, the fundamental function is unchanged: to assure that all members of the community have adequate access to needed services, especially prevention services.

The assurance function is frequently associated with clinical care, but also refers to assurance of the conditions that allow people to be healthy and free from avoidable threats to health—which include access to clean water, a safe food supply, well-lighted streets, responsive and effective public safety entities, and so forth.

This “core functions” framework has proven to be useful in clarifying the fundamental, overarching responsibilities of public health. The three core functions contain a set of ten essential public health services (Table 16.1) (Department of Health and Human Services (DHHS) 1994). Although there is great variation in capacity to implement the ten services, they represent types of activities that public health uses to achieve its

mission to assure the conditions in which people can be healthy.

Whether one views public health through the lens of the core functions or the ten essential services, managing and using information is at the core of public health effectiveness. Assessment, and several of the essential public health services rely heavily on public health **surveillance**, the ongoing collection, analysis, interpretation, and dissemination of data on health conditions (e.g., breast cancer) and threats to health (e.g., smoking prevalence). Surveillance data represent one of the fundamental means by which priorities for public health action are set. Surveillance data serve short term (e.g., in surveillance for acute infectious diseases) and also longer term, (e.g., in determining leading causes of premature death, injury, or disability) purposes. In either case, surveillance data are collected for the purposes of action, either to guide a public health response as in the case of an outbreak investigation, or to help direct public health policy. A recent example of the latter is the surveillance data showing the dramatic rise in obesity in the United States. A tremendous amount of energy and public focus has been brought to bear on this problem, including a major DHHS program, the Childhood Overweight and Obesity Prevention Initiative (DHHS 2011) driven largely by compelling surveillance data.

16.3 Public Health Informatics

Public health informatics has been defined as the systematic application of information science, computer science, and technology to public health practice, research, and learning (Friede et al. 1995; Yasnoff et al. 2000). Public health informatics is distinguished by its focus on populations (versus the individual), its orientation to prevention (rather than diagnosis and treatment), and its governmental context, because public health nearly always involves government agencies. It is a large and complex area that is the focus of another entire textbook in this series (O’Carroll et al. 2003).

The differences between public health informatics and other informatics specialty areas

relate to the contrast between public health and medical care itself (Friede and O'Carroll 1998; Yasnoff et al. 2000). Public health focuses on the health of the community as opposed to that of the individual patient. In the medical care system, individuals with specific diseases or conditions are the primary concern. In public health, issues related to the community as the patient may require "treatment" such as disclosure of the disease status of an individual to prevent further spread of illness or even quarantining some individuals to protect others. Environmental factors, especially ones that affect the health of populations over the long term (e.g., air quality), are also a special focus of the public health domain. Public health places a large emphasis on the prevention of disease and injury versus intervention after the problem has already occurred. To the extent that traditional medical care involves prevention, its focus is primarily on delivery of preventive services to individual patients.

Public health actions are not limited to the clinical encounter—in fact, actions can take place at one or more points in the entire causal chain. In public health, the nature of a given intervention is not predetermined by professional discipline, but rather by the cost, expediency, and social acceptability of intervening at any potentially effective point in the series of events leading to disease, injury, or disability. Public health interventions have included (for example) wastewater treatment and solid waste disposal systems, housing and building codes, fluoridation of municipal water supplies, removal of lead from gasoline, food sanitation and smoke alarms. Contrast this with the modern health care system, which generally accomplishes its mission through medical and surgical encounters.

Public health also generally operates directly or indirectly through government agencies that must be responsive to legislative, regulatory, and policy directives, carefully balance competing priorities, and openly disclose their activities. In addition, certain public health actions involve authority for specific (sometimes coercive) measures to protect the community. Examples include closing a contaminated swimming beach, or a restaurant that fails inspection.

16.4 Information Systems in Public Health

The fundamental science of public health is **epidemiology**, which is the study of the prevalence and determinants of injury, disability and disease in populations. Hence, most public health information systems focus on information about aggregate populations. Disease or risk factor surveillance is the key tool that epidemiologists use to study populations and hence many public health information systems are designed for disease surveillance.

Almost all medical information systems focus almost exclusively on supporting the processes of care for individuals. For example, almost any clinical laboratory system can quickly find a patient's culture results whereas public health practitioners would want to know the time trend of antibiotic resistance for the population served by the clinic.

Most health care professionals are surprised to learn that there is no uniform national routine reporting—never mind information system—for most diseases, injuries, disabilities, risk factors, or prevention activities in the United States. In contrast, France, Great Britain, Denmark, Norway and Sweden have comprehensive systems in selected areas, such as occupational injuries, infectious diseases, and cancer; no country, however, has complete reporting for every problem. In fact, it is only births, deaths, and—to a lesser extent—fetal deaths that are uniformly and relatively completely reported in the U.S. by the National Vital Statistics System, operated by the states and the Centers for Disease Control and Prevention (CDC). If you have an angioplasty (an intravascular procedure to relieve a narrowing in one of the arteries feeding the heart muscle) and survive, nobody at the state or federal level necessarily knows.

The Federal, State or Local (city or county) government settings are responsible for implementing public health information systems in the United States. The information requirements for each setting vary by the degree of information granularity and type of system functionality needed.

Table 16.2 Example types of information systems at a state health department that exchange individual level data with clinics, hospitals and others in the community when required for public health – (Minnesota 2010)

1. Women, Infants and Children (WIC)
2. Children with Special Health Needs
3. Newborn Hearing Screening/Early Hearing Detection and Intervention
4. Birth Defects Information System
5. Blood Lead Information System
6. Infectious Disease Surveillance System
7. Immunization Information System
8. Tuberculosis Control System
9. Refugee/Immigrant Health Information System
10. Sexually Transmitted Infections (STD/SDI) Surveillance System
11. AIDS/HIV Surveillance system
12. Vital Statistics System (e.g. birth and death records)
13. Cancer Surveillance System
14. Breast/Cervical Cancer Screening system
15. Traumatic Brain and Spinal Cord Injury System
16. Public Health Laboratory Information System
17. Newborn Metabolic Screening System

The Federal systems often are large scale such as the National Notifiable Disease Surveillance System (NNDSS) that collects counts of diseases from each state and in this case advanced analysis, reporting and mapping functions are essential.

State health department information systems are often dedicated to a particular disease or condition such as infections disease, cancer or injury registries, immunization information systems and the like. In Minnesota, for example, there are at least 17 such information systems that maintain individual level information and exchange information with hospitals, clinics and other health settings in the community (Table 16.2). These database systems have both analytical capability and case-based management functions. Use of this information is essential to characterize the health of the state population.

The County/City public health departments often interact closely with individuals and families and thus must maintain information systems that support detailed data on public health activities, such as client medication observed therapy

follow-up for a TB case or exposed person or coordination of an asthma action plan.

Public health information systems are designed with special features for population-level analysis and context. These systems involve indexing multiple variables in a database coupled with sophisticated statistical and **Geographic Information System (GIS)** support capabilities often found in a data warehouse. For example, they are optimized for retrieval from very large (multi-million) record databases, and to quickly cross-tabulate, study seasonal and secular trends, and look for patterns by person, place, and time (see example in Fig. 16.1).

Public health agencies retain personal identifiers only as needed by the use of the data and as the law allows. Thus, data submitted to federal agencies often omit personal identifiers. Examples of systems designed to support population-level analysis include CDC's HIV/AIDS reporting system and the NNDSS.

At the national level, the use of personal identifiers in these systems is very limited, and their use is generally restricted to linking data from different sources (e.g., data from a state laboratory and a disease surveillance form). A few examples of these kinds of population-focused systems include CDC systems such as the HIV/AIDS reporting system, which collects millions of observations concerning people infected with the Human Immunodeficiency Virus (HIV) and those diagnosed with Acquired Immunodeficiency Syndrome (AIDS) and is used to conduct dozens of studies (and which does not collect personal identifiers; individuals are tracked by **pseudo-identifier**); the NNDSS operated by CDC in collaboration with the Council of State and Territorial Epidemiologists (CSTE) in which state epidemiologists report some 77 conditions (for 2011; the exact number is set each year and varies as conditions wax and wane) every week to the CDC (and which makes up the center tables in the Morbidity and Mortality Weekly Report [MMWR]).

Assessment of the magnitude of non-reportable health conditions and surveillance for these conditions, usually managed by state health departments and federal health agencies (largely

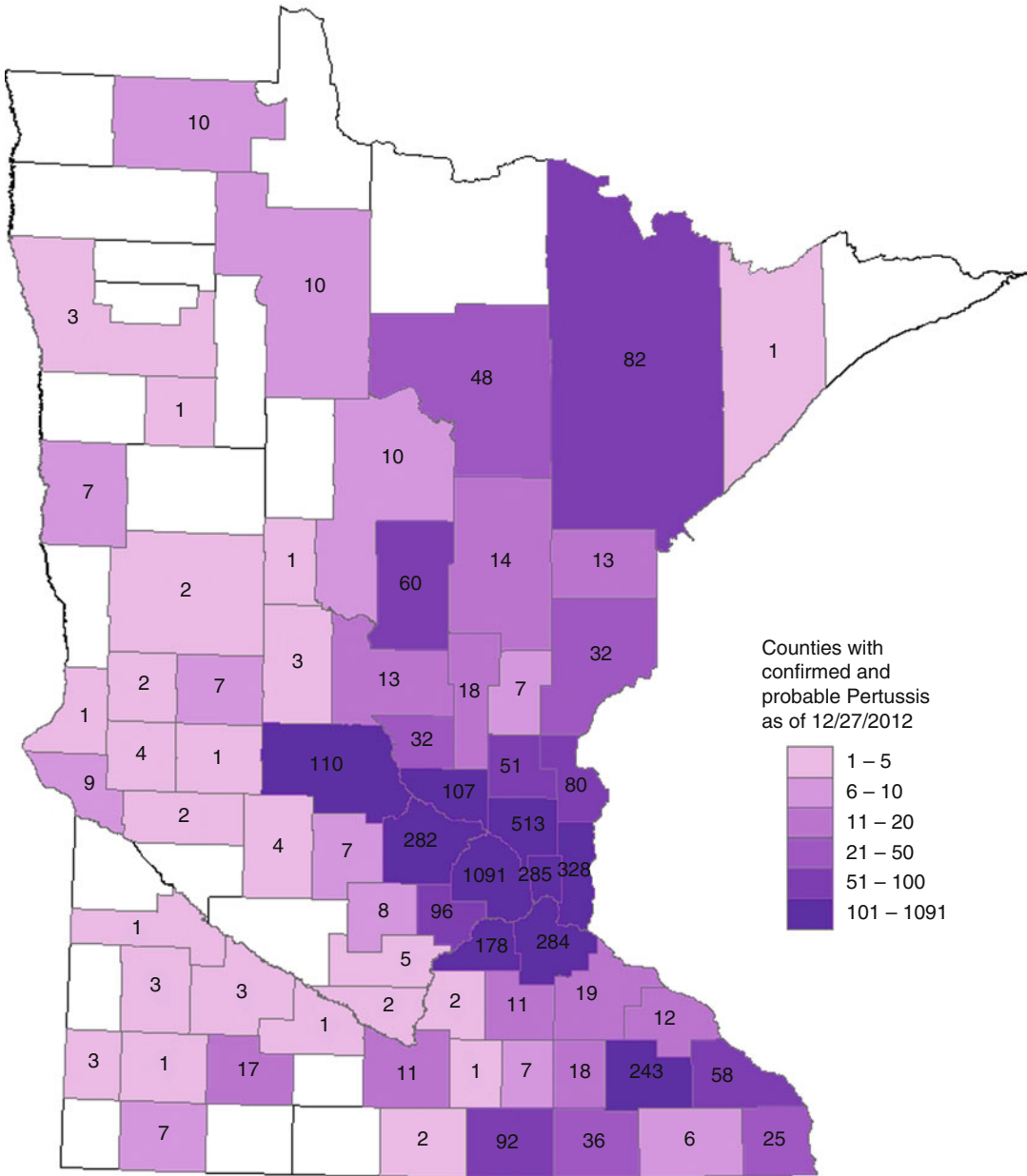


Fig. 16.1 Example: confirmed, probable, and suspect pertussis case counts by county as of December 13, 2012 (Source: Minnesota Department of Health; Immunization Program, 2012)

the CDC), provide periodic estimates of risk factors, incidence and prevalence of diseases. Because these data derive largely from population samples, it is often impossible to obtain estimates at a level of geographic detail finer than a region or state. Moreover, many of the behavioral indices are patient self-reported (although

extensive validation studies have shown that they are good for trends and sometimes are more reliable than data obtained from clinical systems). In the case of special surveys, such as CDC’s National Health and Nutrition Examination Survey (NHANES), there is primary data entry into a CDC system. The data are complete, but

the survey costs many millions of dollars, is done only every few years, and requires years for the data to be made available.

Disease registries track, often completely, the incidence of certain conditions, especially cancers, birth defects, injuries, and conditions associated with environmental contamination. They tend to focus on one topic or to cover certain diseases for specific time periods. Most of these surveillance systems rely on health care providers to submit the data, thereby leading to incomplete reporting (Overhage et al. 2008), even as it becomes increasingly automated from laboratory information and EHR systems.

While separate disease-specific information systems served their purposes well for many years, issues of duplicate data entry and increasing pressures to exchange data electronically with clinical and other systems led to the creation of the Public Health Information Network (PHIN). The PHIN addresses this issue by promoting the use of data and information system standards to advance the development of efficient, integrated, and interoperable surveillance systems at federal, state and local levels (CDC 2011). This activity is designed to facilitate standards-based electronic transfer of information between systems (see Chap. 7), reduce provider burden in submitting the information, and enhance both the timeliness and quality of information provided. Standards for immunization transactions, reportable electronic laboratory results and transactions for syndromic surveillance, are being integrated into the requirements for achieving the various stages of **meaningful use**. Submission of data such as immunizations and disease reports from EHRs to public health is part of the meaningful use incentive program (see Chaps. 12, 14, and 22) with the ultimate goal of bi-directional communications between public health departments and clinicians.

Now that historical and epidemiological forces are making the world smaller and causing lines between medicine and public health to blur, systems will need to be multifunctional, and clinical and public health systems will, of necessity, coalesce. Public health systems need to inform the state of the health ecology. To fill that need, pub-



Fig. 16.2 Example: public health officials respond to potential bio-terrorism event or exposure bio-threat as a result of a natural disaster (Source: LaVenture M, Minneapolis, Minnesota 2013)

lic health and clinical informaticians will need to work closely together to build the tools to study and control new and emerging infectious diseases, bioterrorism threats, and support efforts to respond to and manage natural disasters and other environmental effects on health (see photo in Fig. 16.2). For example, in the late 1990's, Columbia Presbyterian Medical Center and the New York City Department of Health collaborated on the development of a tuberculosis registry for northern Manhattan, and the Emory University System of Health Care and the Georgia Department of Public Health built a similar system for tuberculosis monitoring and treatment in Atlanta. It is not by chance that these two cities each developed tuberculosis systems; rather, tuberculosis is a perfect example of what was once a public health problem (that affected primarily the poor and underserved) coming into the mainstream population as a result of an emerging infectious disease (AIDS), immigration,

increased international travel, multidrug resistance, and our growing prison population. Hence, the changing ecology of disease, coupled with revolutionary changes in how health care is managed and paid for, will necessitate information systems that serve both individual medical and public health needs.

16.5 Immunization Information Systems: A Public Health Informatics Example

Immunization Information Systems (IIS) are confidential, computerized, population-based systems that collect and consolidate vaccination data from vaccine providers and offer tools for designing and sustaining effective immunization strategies at the provider and program levels (MMWR 2011).¹

IIS represent a good example for illustrating the principles of public health informatics. In addition to their orientation to prevention, they can function properly only through continuing interaction with the health care system; in fact, they were designed for use primarily in the clinical setting. Although IIS are among the largest and most complex public health information systems, the many successful implementations show conclusively that it is possible to overcome the challenging informatics problems they present. The maturity and value of IIS is reflected in the inclusion of provider and hospital reporting to IIS as a “Meaningful Use” objective.

The major functions of IIS include the ability to accept immunization records either through manual entry or electronically using a variety of file formats and messaging standards (see below), providing on-line secure access to patient immunization records 24/7, providing vaccine forecasting/decision support based on patient age and immunization history, supporting vaccine inventory management and vaccine ordering, producing official immunization records for school and other enrollment, generating immunization coverage reports for an individual provider, clinical

practice or jurisdiction, and supporting Vaccine Adverse Event Reporting.

16.5.1 History and Background of IIS

Childhood immunizations have been among the most successful public health interventions, resulting in the near elimination of nine vaccine preventable diseases that historically extracted a major toll in terms of both morbidity and mortality (IOM, 2000). The need for IIS stems from the challenge of assuring complete immunization protection for the approximately 10,800 children born each day in the United States in the context of three complicating factors: the scattering of immunization records among multiple providers; an immunization schedule that has become increasingly complex as the number of vaccines has grown; and the conundrum that the very success of mass immunization has reduced the incidence of disease, lulling parents and providers into a sense of complacency.

IIS must be able to exchange a high volume of immunization information accurately and consistently, so they were the first public health information systems to develop HL7 messaging guides (see Chap. 7), beginning in 1995.

In addition to messaging standards, the CDC and IIS community also developed functional standards (Table 16.3), codifying years of experience in refining system requirements. CDC and state IIS have established a detailed measurement system containing about 100 measures for tracking progress that annually assesses adherence to the 12 functions and other functional and use metrics (see example in Fig. 16.3). Further formalizing the public policy commitment to the development of IIS, the national Healthy People 2020 objective is to increase to 95 % the percentage of children aged <6 years whose immunization records are housed in a fully operational IIS (DHHS 2010). In 2011, 20 states and 3 of 6 major cities measured had met this objective (Fig. 16.4)

Numerous best practice guidelines have been developed by the IIS community’s American Immunization Registry Association (AIRA) to help ensure ongoing quality improvement, efficiency and increased standardization.

¹ <http://www.cdc.gov/mmwr/> (accessed 4/26/13).

Table 16.3 Twelve functional standards for immunization registries (CDC, 2002)

1. Electronically store data regarding all National Vaccine Advisory Committee-approved core data elements
2. Establish an IIS record within 6 weeks of birth for each child born in the catchment area
3. Enable access to vaccine information from the IIS at the time of the encounter
4. Receive and process vaccine information within 1 month of vaccine administration
5. Protect the confidentiality of medical information
6. Protect the security of medical information
7. Exchange vaccination records by using Health Level 7 standards
8. Automatically determine the immunization(s) needed when a person is seen by the health care provider for a scheduled vaccination
9. Automatically identify persons due or late for vaccinations to enable the production of reminder and recall notices
10. Automatically produce vaccine coverage reports by providers, age groups, and geographic areas
11. Produce authorized immunization records
12. Promote accuracy and completeness of IIS data

16.5.2 Key Informatics Issues in Immunization Information Systems

The implementation, upgrading and management of IIS present challenging informatics issues in at least four areas: (1) interdisciplinary communications; (2) organizational and collaborative issues; (3) funding and sustainability; and (4) system design and interoperability. While the specific manifestations of these issues are unique to IIS, these four areas represent the typical domains that must be addressed and overcome in most public health informatics projects.

16.5.2.1 Interdisciplinary Communications

Interdisciplinary communications is a key challenge in any biomedical informatics project—it is certainly not specific to public health informatics. To be useful, a public health information system must accurately represent and enable the complex concepts and processes that underlie the specific business functions required. Information systems represent a highly abstract and complex

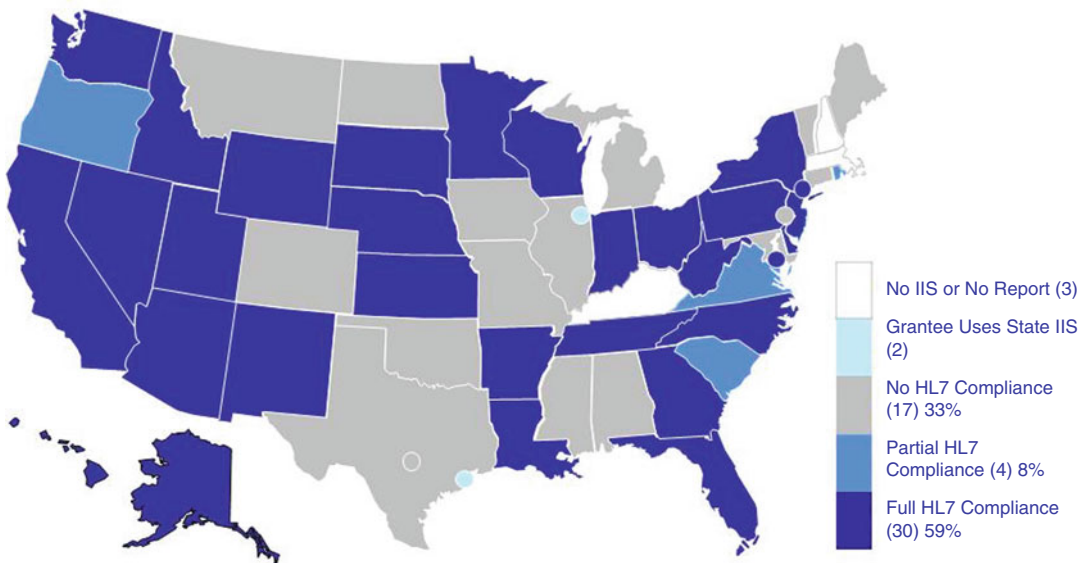


Fig. 16.3 Example: compliance with HL7 Messaging Standards in a Grantee Immunization Information System – United States and six cities, 2011 (Source: Urquhart, GA, Centers for Disease Control and Prevention,

Chief, Immunization systems Support Branch; presentation to the Association of Immunization Managers, 2010 program managers meeting)

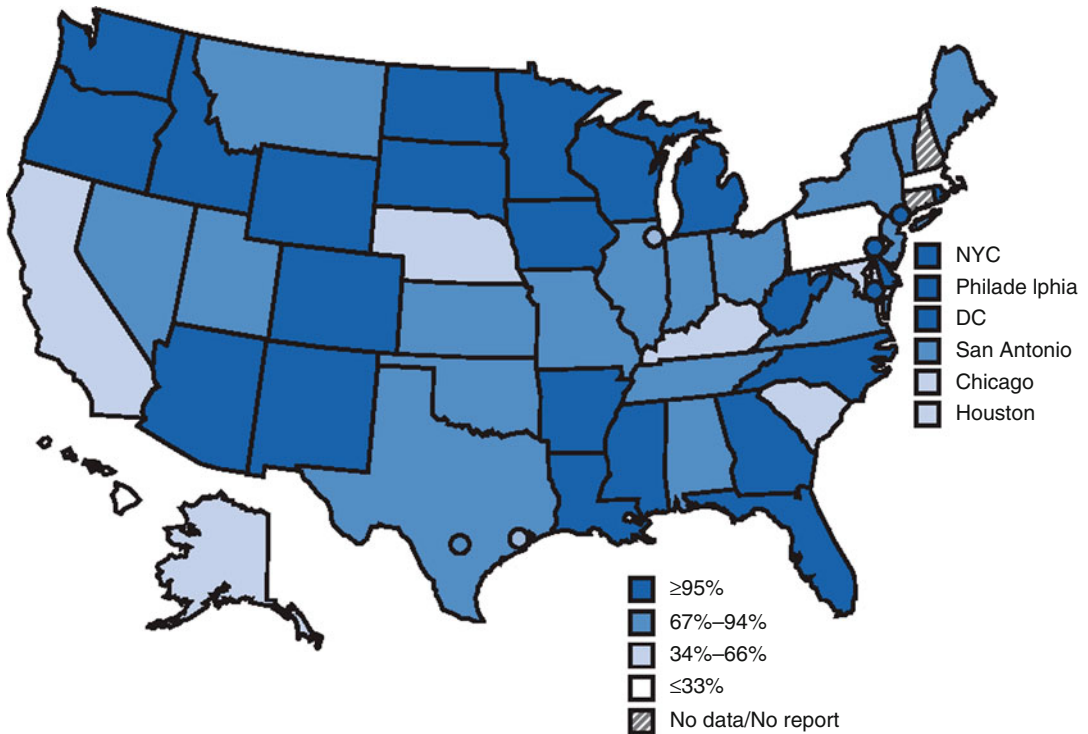


Fig. 16.4 Example: percentage of children aged <6 years participating in an Immunization Information System — United States, five cities,[†] and the District of

Columbia, 2011 (Source: CDC. Progress in immunization information systems—United States 2011. *MMWR* 2013;62(03):48–51)

set of data, processes, and interactions. This complexity needs to be discussed, specified, and understood in detail by a variety of personnel with little or no expertise in the terminology and concepts of information technology. Therefore, successful IIS implementation and enhancements require clear communication among public health specialists, immunization specialists, providers, IT specialists, and related disciplines, an effort complicated by gaps in a shared vocabulary and differences in the usage of common terms from the various domains.

To deal with the communications challenges, particularly between IT and public health specialists, it is essential to identify an interlocutor who has familiarity with both information technology and public health. The interlocutor should spend sufficient time in the user environment to develop a deep understanding of the information processing context of both the current and proposed systems. It is also important for individuals from all

the disciplines related to the project to have representation in the decision-making processes.

16.5.2.2 Organizational and Collaborative Issues

The organizational and collaborative issues involved in operating and upgrading an IIS are challenging because of the large number and wide variety of users, most of whom are outside the IIS organization. Each of the user groups has distinct needs, including clinicians (to ensure age-appropriate vaccination and for vaccine management and ordering), schools (to ensure student adherence to state school immunization laws), health plans (to measure immunization coverage among beneficiaries and perhaps by provider), local health departments (to assess immunization coverage in their jurisdiction and identify children who have fallen behind and require outreach), and CDC (for accountability of federally-funded vaccines and IIS funding).

Ensuring these diverse needs are understood, balanced and effectively met can be daunting on the typically slim governmental budgets on which IIS must operate.

Governance

Governance issues are also critical to success of implementation or enhancements to IIS. All the key stakeholders need to be represented in the ongoing, open and transparent decision-making processes, guided by a mutually acceptable governance mechanism. IIS require established rules for identifying needed enhancements, prioritizing them across the often disparate needs of diverse users, and effectively managing and communicating the changes as they are developed and implemented. Governance can also be used for establishing metrics for progress, such as provider sites enrolled and trained, setting other priorities, and for review of confidentiality policies.

Legislative and Policy Issues

Legislative and policy issues are important aspects of the informatics challenges of IIS. State laws typically govern who has access to IIS data for what purposes, so system design must accommodate multiple levels of role-based authorized access to functionality. A major issue is whether patient/parent consent is required before submission of immunization data to IIS, and, if so, how that consent is communicated and managed in the system. IIS must also be able to record that the patient has declined to receive vaccines for religious or other reasons as defined in state law, and use that indicator to suppress vaccine forecasting/decision support messages and reminder-recall notices. Some jurisdictions have enacted regulations requiring providers to submit immunization data to IIS. Such a regulatory approach to ensuring information completeness is less burdensome as automated electronic file submissions have largely replaced manual data entry. Negotiating policy for interstate access and data exchange is another key issue.

16.5.2.3 Funding and Sustainability

Funding and sustainability are continuing challenges for all IIS. Naturally, an important tool for

securing funding is development of a business case that shows the anticipated costs and benefits of IIS. A substantial body of evidence now shows benefits, effectiveness and costs of IIS (Guide to Community Preventive Services 2010). However, many of the currently operational IIS had to develop their business cases prior to the availability of good quantitative data.

Specific benefits associated with IIS include preventing duplicative immunizations, eliminating the necessity to review the vaccination records for school and day care entry, and efficiencies in provider offices from the immediate availability of complete immunization history information and patient-specific vaccine schedule recommendations. The careful review of the evidence on effectiveness, costs and benefits of specific immunization IIS functions may also be helpful in prioritizing system enhancement requirements.

16.5.2.4 System Design and Interoperability

System design and interoperability are important factors in the success of IIS. Difficult design issues include data acquisition, database organization, identification and matching of individuals, generating immunization recommendations, access to data, protocols for electronic exchange and interoperability, and reports related to clinic practice and community rates of immunization. Acquiring immunization data is a challenging system design issue and an area of considerable IIS change as electronic health record use becomes more common, new adolescent and adult immunizations are added to IIS, and a broader scope of settings like pharmacies submit information. Within the context of busy pediatric and primary care practices (where the majority of immunizations are given) the data acquisition strategy must of necessity be extremely efficient and should result in no additional work for participating providers. Use of certified EHR systems can support this strategy; however, only a minority of physician practices is currently using EHRs and few EHR vendors have integrated IIS query and exchange into their software.

Database design must support the desired IIS functions and allow efficient implementation of

these capabilities. The design must consider operational needs for data access for an individual record and calculating individual forecasts of needed immunizations, and the requirements for population-based immunization assessment, management of vaccine inventory, and generating recall and reminder notices. One example of a particularly important database design decision for IIS is whether to represent immunization information by vaccine or by antigen. Vaccine-based representations map each available preparation, including those with multiple antigens, into its own specific data element. Antigen-based representations translate multi-component vaccines into their individual antigens prior to storage. In some cases, it may be desirable to represent the immunization information both ways. Specific consideration of required response times for specific queries must also be factored into key design decisions.

Identification and matching of individuals within IIS is another critical issue. Because it is relatively common for an individual to receive immunizations from multiple providers, any system must be able to match information from multiple sources to assemble a complete record of immunizations. In the absence of a national unique patient identifier, most IIS assign an arbitrary number to each individual and use a matching algorithm, which utilizes multiple items of demographic information to assess the probability that two records are really from the same person and can detect duplicate reports of an immunization. Development of such algorithms and optimization of their parameters has been the subject of active investigation in the context of IIS, particularly with respect to **deduplication** (Miller et al. 2001).

Another critical design issue is generating vaccine recommendations from an individual's prior immunization history, based on guidance from the CDC's Advisory Committee on Immunization Practices (ACIP). As more vaccines have become available, both individually and in various combinations, the immunization schedule has become increasingly complex, especially if any delays occur in receiving doses, an individual has a contraindication, or local issues require special consideration. The language used

in the written guidelines can be ambiguous with respect to definitions, e.g., for ages and intervals, making implementation of decision support systems problematic. Considering that the recommendations are updated relatively frequently, maintaining software that produces accurate immunization recommendations is a continuing challenge. Accordingly, the implementation, testing, and maintenance of decision support systems to produce vaccine recommendations has been the subject of extensive study (Yasnoff and Miller 2003).

Finally, easy access to the information in IIS is essential. While independent web based interfaces are common, the ideal is to provide a seamless query launched within the context of the provider's EHR workflow and having IIS information and forecast returned and incorporated into the EHR. Similarly the design should support efficient access to summary reports on immunization rates for a clinic or community, reports on children who are behind schedule and support delivery of electronic reminder or recall notices to support prevention. Consumer direct access to their own immunization record is desirable; however, there are design considerations regarding security, allowable data views and editing rights.

16.6 Conclusions and Future Challenges

Public health informatics may be viewed as the application of biomedical informatics to populations. In a sense, it is the ultimate evolution of biomedical informatics, which has traditionally focused on applications related to individual patients. Public health informatics highlights the potential of the health informatics disciplines as a group to integrate information from the molecular to the population level. Effective public health information systems can help to assure prevention actions, timely monitoring of disease patterns, and rapid responses to outbreaks, thereby saving lives and money.

Public health informatics and the development of **health information infrastructure** (see Chap. 13) are closely related. Public health informatics supports the population assessment,

assurance and policy development roles of public health. In contrast, health information infrastructures focus on medical care to individuals but connect providers and patients within a population. Ideally these two areas work together supporting both community health assessment and individual care. In the past, public health and health care have not traditionally interacted as closely as they should. In a larger sense, both really focus on the health of communities—public health does this directly, while the medical care system does it one patient at a time. However, it is now clear that medical care must also focus on the community to integrate the effective delivery of services across all care settings for all individuals (Institute of Medicine 2011a). Public health informatics confronts many challenges including the varied ways governments organize public health practice, the legal issues involved in inter-institutional information systems and defining user information and system needs in a multi-stakeholder discipline that is public health.

Public health systems frequently involve non-health organizations such as law enforcement and parks and recreation departments. Thus public health informaticians must adopt methodologies that bridge professional and organizational divides. The Public Health Informatics Institute's Collaborative Requirements Methodology is one such example (PHII 2011)

Despite the focus of many current public health informatics activities on population-based extensions of the medical care system (leading to the orientation of this chapter), applications beyond this scope are both possible and desirable. Indeed, the phenomenal contributions to health made by the hygienic movement of the nineteenth and early twentieth centuries suggest the power of large-scale environmental, legislative, and social changes to promote human health (Rosen 1993). Public health informatics must explore these dimensions as energetically as those associated with prevention and clinical care at the individual level.

The effective application of informatics to populations through public health is a key challenge of the twenty-first century. It is a challenge we must accept, understand, and overcome if we want to create an efficient and effective health care system as well as truly healthy communities for all.

Suggested Readings

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- Yasnoff, W. A., O'Carroll, P. W., Koo, D., Linkins, R. W., & Kilbourne, E. M. (2000). Public health informatics: Improving and transforming public health in the information age. *Journal of Public Health Management and Practice*, 6(6), 67–75. A concise yet comprehensive introduction to the field.

Questions for Discussion

1. How might the trend of widespread adoption of electronic health records and increasing consumer interest in health information affect public health informatics?
2. How can the successful model of immunization registries be used in other domains of public health (be specific about those domains)? How might it fail in others? Why?
3. A significant and increasing percentage of the US GDP is spent on medical care. How could public health informatics

help to use those monies more efficiently? Or lower the figure absolutely?

4. Compare and contrast the database desiderata for clinical versus public health information systems. Explain it from non-technical and technical perspectives.
5. If public health informatics (PHI) involves the application of information technology in any manner that improves or promotes human health, does this necessarily involve a human “user” that interacts with the PHI application? For example, could the information technology underlying anti-lock braking systems be considered a public health informatics application? Provide other examples.
6. What is the relationship between public health informatics and the developing health information infrastructure (HII) (see Chap. 13)? How might public health informatics inform the developing HII?
7. How will cloud computing (shared configurable computing resources including networks, servers, storage, applications, and services), and mobile technology transform public health informatics?