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Design and Assessment of a Common, Multi-National Public Health Informatics Infrastructure to Enable H1N1 Influenza Surveillance

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Abstract

Public health organizations in different nations face similar needs for gathering and analyzing population health data to detect and manage infectious disease outbreaks, including outbreaks of the 2009 Novel H1N1 Influenza A virus or "swine flu." This paper presents our progress to date on the design and assessment of a multi-national public health informatics infrastructure for data collection and disease surveillance. This initial work, under the aegis of an open health tools collaborative, lays the foundation for best practices in patient care and public health preparedness in the national health IT sector. This multinational collaboration is the first to identify essential electronic health record (EHR) data sets as well as standard public health informatics indicators to electronically monitor a notifiable public health condition internationally.

Keywords:

Semantic interoperability, Crosswalk, Public health informatics; H1N1, Surveillance, Electronic health record, EHR, Open health tools, OHT, Open source software

Introduction

With advent of a severe *Novel H1N1 Influenza A* pandemic in the 2009-2010 season, there is a need for improved awareness and response in national public health efforts. As a result of increased cases globally of H1N1 Influenza A, the need is both emergent and evident for increased and integrated multi-national surveillance and tracking for the pandemic.

Comprehensive large-scale surveillance requires the integration of health IT data streams including point-of-care electronic medical record data into national and international influenza surveillance systems [1, 2]. At present, there is minimal or no integration between the clinical delivery systems and public health organizations in the organizations and national settings studied, a gap targeted in the focus of this work.

Recognizing this gap, this study sought to address the following problems: (i) identifying what are the known national-level data information sources within countries (ii) coordinating overlapping public health informatics efforts across nations in the face of limited budgets for response; (iii) the feasibility of analyzing public health data in a cross-national manner. This paper is designed to help provide an insight into the international e-health information streams and data sets available to allow consistent world-wide surveillance and assist in bridging this identified gap between clinical delivery and public health contexts.

This collaborative endeavor identified the existing national data streams that can be used to answer surveillance questions as well as identify indicators of importance to public health management of influenza. The multinational collaboration is comprised of individuals from various United States institutions and worldwide public health systems, including the [US] Centers for Disease Control and Prevention (CDC), the [US] Indian Health Service (IHS), and the Office of Health Protection (OHP), Australian Government Department of Health and Ageing Canberra, Australia, in all case bridging both informatics and epidemiology divisions of each organization.

The objective of the multinational collaboration is to foster sharing among major e-health programs globally to promulgate common knowledge for health information technology best-practices in patient care and public health preparedness. The initial focus of this study has been centered on the determination of de-identified health IT data streams contained within point-of-care electronic medical records. These data streams provide a content source of rich medical information that the authors are asserting can be a critical asset for use in national influenza surveillance systems to prepare for and respond to the worldwide pandemic. Moreover, our findings are that sufficient commonalities exist

among existing health IT data streams in different organizations so as to allow for their use in cross-national pandemic influenza surveillance. This information is a necessary foundation for the dynamic sharing of information across the different institutions and countries involved. Based on the feasibility analysis presented here, further work will continue in order to develop a set of common data specifications for e-health-based large-scale multi-national surveillance systems.

Methods

The design and assessment method used in the study consisted of four main steps. First, a set of three test cases of national-level public health systems were chosen through which to conduct the assessment. These were the US Indian Health Service, the Australian National Influenza Surveillance Systems, and the United Kingdom Health Protection Agency.

Second, an exercise to evaluate the existing e-health data streams available in the context of each health system was undertaken. Third, a consensus set of key Novel H1N1 pandemic surveillance indicators was selected for the underlying multi-national surveillance system design. Fourth, each indicator in the consensus set was cross-walked against the e-health data streams to evaluate the feasibility of integrating these streams for multi-national pandemic surveillance.

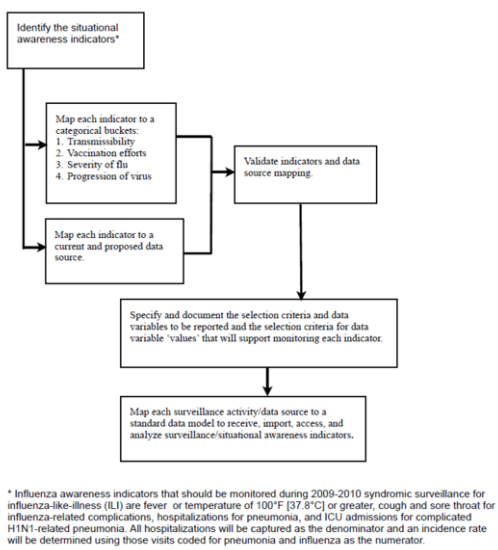

Figure 1 - Design and assessment process for an e-health-based pandemic surveillance system

Results

Each of the three health systems chosen were comparatively evaluated against the coupling of population based and individual-patient based health data streams used for surveillance. This relationship spanned from very tight coupling at the US Indian Health Service, to indirect coupling in the UK NHS, to traditional parallel data streams in the Australian health system (see Table 1).

Table 1 - National Health System Data Streams

Health System	Integration Level	Representative Data Streams
Indian Health Service (United States)	Tightly integrated population and patient based data streams with record-linked aggregates	Resource and Patient Management System (RPMS) and Point of Care (POC) EHR – Electronic Health record with integrated public health functions including syndromic and case-based surveillance
Department of Health and Ageing (Australia)	Traditional hybrid system with sentinel, case-based, and population-based surveillance without row-level case reporting	- Laboratory confirmed influenza surveillance - GP sentinel surveillance - ED sentinel surveillance - Laboratory surveillance - ICU surveillance - Community absenteeism - National syndromic call centre surveillance - Online syndromic survey
National Health Service (United Kingdom)	Patient-based national identifier-linked case reporting with de-indentified aggregates	- NHS Care Record Service ["Spine"] for case-based and sentinel provider surveillance - Call Center for Syndromic Surveillance

The varied level of coupling between the population aggregate and the individual patient level has implications for the ability to effectively integrate large-scale surveillance systems with traditional case-based and sentinel provider surveillance. For instance, the US Indian Health Service Resource and Patient Management System (RPMS) is an integrated health IT solution in use nationwide within the entire health system for native Americans. The RPMS provides the ability to capture individual patient- specific data at point-of-care that can then be used for public and population health management and surveillance. This allows direct and seamless "drill-down" from population aggregates and the automated linkage of syndromic surveillance with case notification of confirmed cases.

On the other hand, the Australian Department of Health and Ageing (Canberra) utilizes a traditional hybrid approach with multiple systems as data stream sources for their national influenza surveillance system. The case-specific streams include laboratory confirmed notifications from the National Notifiable Diseases Surveillance System (NNDSS), and a national online web-enabled outbreak case reporting system (NetEpi). The de-identified aggregate surveillance systems include a general practitioner sentinel surveillance system, Emergency Department presentations of ILI at sentinel

hospital sites, sentinel community absenteeism, national call centre data [4] and an online self-reporting syndromic influenza surveillance system, FluTracking [5]. The integration of de-identified aggregate data with case-specific data on a national level requires a record linkage algorithm whose ultimate validity is constrained by the levels of de-identification and aggregation.

This variation in the coupling characteristics of the health IT data streams provided an objective constraint against which to design the indicator set for a multi-national pandemic surveillance system. The indicators had to be specific enough to be valid and general enough to be stable and reportable from both tightly-coupled as well as hybrid data streams. For this step, an iterative process was used to identify a set of Influenza-like Illnesses (ILI) and H1N1 indicators that used appropriate standards and which would be reportable across the range of health IT data steams.

The indicators were also chosen to reflect a range of epidemiologically important categories including ILI symptomology, transmissibility/progression, severity, vaccine effectiveness, and healthcare utilization. Indicators considered in the study included both natural language processing (NLP) and formal terminologies such as ICD9 and, ICD10. The group first identified situational awareness indicators that could be monitored for syndromic surveillance of influenza-like-illness (ILI). The indicators identified for pandemic multi-national surveillance of ILI were: (i) fever or temperature of 100°F [37.8°C] or greater, (ii) cough and sore throat for influenza-related complications, (iii) self-report of fever and other ILI symptoms. For transmissibility/progression, indicators were (iv) disposition from outpatient to inpatient when hospitalization occurs with (v) specific indication of hospitalizations for pneumonia. For severity, indicators chosen were (vi) mortality rates associated with H1N1/ILI cases and (vii) ICU admissions for complicated H1N1-related pneumonia. Lastly for utilization and vaccinations, indicators were (viii) health care utilization (number of beds utilized and intensive care units-ICUs), and (ix) adverse events associated with the H1N1 vaccines.

Lastly, a collective cross-walk of these consensus data indicators was carried out against the national health system data streams to assess the feasibility of multi-national pandemic surveillance. Of the set of 27 indicator-data-stream combinations, the three different national health IT systems were able to satisfy 24 reporting streams, for a score of 89% for the eight indicators chosen. Secondly, the data collection and evaluation for the indicator selection resulted in the identification of common data elements and alignment of data sets to candidate disease indicators to foster semantic interoperability for H1N1 electronic multi-national surveillance.

Discussion

One central challenge for the design of national surveillance systems in the medium term is to reconcile (a) the specificity of older, established surveillance data streams based on clinician-diagnosed case reports or sentinel provider syndromic surveillance with (b) large-scale, higher-throughput, timelier but less specific automated surveillance data based on national health IT infrastructure [6].

During a significant epidemic the sensitivity and specificity of these laboratory based and syndromic influenza surveillance systems may need to be optimized. Each type of system has advantages. For example, the timeliness of syndromic surveillance may outweigh its lower specificity than clinical confirmed or laboratory confirmed surveillance systems in certain situations, such as during an emerging outbreak. Once significant clusters are identified during these syndromic systems it then may be necessary to confirm laboratory evidence for each cluster. During a pandemic, it may not be necessary to gather laboratory evidence on every case.

Recognition of differences among international surveillance systems offers the possibility to change the case definition based upon the sensitivity and specificity of early data from countries initially involved in an epidemic situation. Preparation for an epidemic or pandemic from a novel subtype, international cooperation to identify data elements and proposed data monitoring may help increase sentinel awareness and more timely interventions. A further evaluation has begun on refining the indicators to the best level of granularity in terms of case definitions and geographic reporting segments to find the optimal trade-off between specificity and generalizability across the different health IT systems.

Conclusion

This work includes input from participating countries, but is limited to participants from the respective national e-health and surveillance authorities. Future work would benefit from involvement of additional countries. This work also points to the need for integration of public health surveillance within the point of care HIT solutions. Development of meaningful use criteria internationally that encourage the addition of public health functionality within electronic health records may be a critical path for long term improvements in public health surveillance. Similarly, future work such as the development of open-source software components to facilitate the extraction and transformation of identified indicators may promote multinational participation and involvement in pandemic influenza surveillance. This multinational collaboration around surveillance and health IT infrastructure may initiate a more widespread conversation on the critical need for integration of public health programs and health information technology infrastructure development.

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Table 2 - The table summarizes the flu specifications where the empirical data set of influenza indicators are cross walked and validated.

Indicator		Population under surveillance	Common Indicator Definition	Indian Health Service – Integrated Health System	Office of Health Protection, Australian Nat'l Influenza Surveillance Systems	United Kingdom Health Protection Agency
Monitor Transmissibility of Flu	Syndromic	Primary Care	▪ ILI - specific symptomology – fever, throat pain or sore throat, cough	▪ ICD 9 Code definitions: fever 780.6, 780.60, 780.61; pain, throat 784.1, 462; cough 786.2 ▪ 100% of charts reviewed electronically on a daily basis and exported to national epi center each day	▪ GP Sentinel Surveillance, ILI = fever, cough and fatigue	▪ Sentinel Primary Care Surveillance, Royal College of General Practitioners, ILI, pneumonia, acute bronchitis
		Community Based Self Reporting			▪ National Call Ctr Hotline; FluTracking (syndromic survey, self-reported illness); ▪ Sentinel absenteeism data from national employer ▪ Sentinel childcare absenteeism	▪ National Health Service nurse-led call centers, Community Syndromic Surveillance, colds, flu, fever
	Lab Confirmed	Public health notifiable disease surveillance system	▪ Laboratory confirmation of influenza	▪ Laboratory results at point of care in RPMS HIT system	▪ National Notifiable Diseases Surveillance System	▪ First few hundred surveillance system and enhanced surveillance system
		Sentinel School-based syndromic surveillance	▪ILI	▪ ILI with swabs at point of care in reservation based schools using RPMS HT system	▪Not available at national level	▪ Boarding schools in Medical Officers of Schools Association and HPA Scheme
		Primary care	▪ Sentinel primary care surveillance with virilogical monitoring	ILI with swabs when indicated clinically	▪ILI with swabs from a sample of patients in some regional areas	▪ ILI with swabs from a sample of patients
		Hospitals	▪ Disposition from outpatient to inpatient (hospitalizations)	▪ Incidence rate: hospitalizations (as the denominator) and visits coded for pneumonia / influenza (numerator)	▪ Emergency Department sentinel hospital surveillance	▪ All patients admitted to hospital with severe respiratory illness, with virological monitoring
Vaccination	Vaccine effective-		▪ Adverse events - to the H1N1 vaccine	▪ Adverse events instructed by the Food and Drug Administration	▪ Adverse Events Following Immunization Surveillance ▪ Adverse Drug Reactions Reporting	
Severity Measure	Mortality Rates - Virulence	Laboratory surveillance networks	▪ Mortality rates-electronic death reporting ▪ Subtyping, antigenic characterization, sensitivity / susceptibility to anti-virals	▪ Death reporting not utilized due to loss to follow-up. ▪ Delayed monitoring via Death Certificate Data	▪ Deaths data from sentinel hospital surveillance; ▪ ICU admissions and clinical severity; ▪ Drug resistance, antigenic characterization, shift and drift	▪ Death registrations, total respiratory deaths, mortality excess estimation; ▪ HPA Regional Microbiology Network and National Laboratory Reporting Scheme Antiviral Resistance Monitoring and Viral Sequencing
Healthcare Utilization			▪ Utilization of hospital beds, ICUs, and respiratory ventilators	▪ RPMS – Resource and Patient Management System collects this data, but it is not utilized.	▪ Hospital bed capacity, ventilator usage and extracorporeal membrane oxygenators	

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