Syndromic Surveillance Discussion Paper

Provincial Infectious Diseases Advisory Committee (PIDAC)

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The Ontario Agency for Health Protection and Promotion (Public Health Ontario) is a Crown corporation dedicated to protecting and promoting the health of all Ontarians and reducing inequities in health. As a hub organization, Public Health Ontario links public health practitioners, front-line health workers and researchers to the best scientific intelligence and knowledge from around the world. Public Health Ontario provides expert scientific and technical support relating to communicable and infectious diseases; surveillance and epidemiology; immunization; health promotion, chronic disease and injury prevention; environmental and occupational health; health emergency preparedness; and public health laboratory services to support health providers, the public health system and partner ministries in making informed decisions and taking informed action to improve the health and security of Ontarians.

The Provincial Infectious Diseases Advisory Committee on Surveillance (PIDAC-S) was established to advise Public Health Ontario on the surveillance of infectious diseases and other microorganisms of epidemiologic significance to the health of Ontarians. The committee draws on the dedication of health care practitioners with expertise in infectious disease; infection prevention and control; epidemiology; and public health.

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This document was developed by the Provincial Infectious Diseases Advisory Committee on Surveillance. PIDAC-S is a multidisciplinary scientific advisory body that provides evidence-based advice to Public Health Ontario regarding multiple aspects of infectious disease identification, prevention and control. The work of PIDAC-S is guided by the best available evidence and updated as required. Best practice documents and tools produced by PIDAC-S reflect consensus positions on what the committee deems prudent practice and are made available as a resource to public health and health care providers.

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NOTES

This document is intended to provide best practices only. Health care settings are encouraged to work towards these best practices in an effort to improve quality of care.

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Purpose of the Document

This report describes sources of syndromic surveillance data, along with their applications and attributes, and it summarizes the published evidence related to their effectiveness as part of a public health surveillance system. In this report, the use of such data will be described in the context of infectious diseases surveillance only. Syndromic data used for other purposes, such as bioterrorism preparedness or detection of heat-related illnesses, will not be addressed. We will also outline relevant characteristics of syndromic surveillance systems, such as timeliness and automation, as they inform recommendations for implementation in Ontario.

Background

Public health surveillance is the ongoing systematic collection, analysis, interpretation and dissemination of data for use in public health action to reduce morbidity and mortality and to improve health.[1] Surveillance of health-related events, including those related to infectious diseases, are used to measure the burden of illness, monitor trends, evaluate interventions and guide public health action. Surveillance also functions as a tool to help formulate hypotheses for further research.

Clinical and laboratory diagnostic methods have long been the gold standard for communicable infectious disease surveillance and the primary sources of information for traditional surveillance systems. However, there are many instances in which this information is neither complete nor timely enough to allow for the most effective public health intervention efforts. For example, most individuals with symptoms of influenza-like illness (ILI) often do not present for medical care, and thus are not eligible for laboratory testing or clinician diagnosis. In an attempt to enhance the comprehensiveness of disease surveillance and timeliness of outbreak detection, many public health jurisdictions have begun monitoring a variety of syndromic surveillance data sources in the past decade.

For the purposes of this paper, the term *syndromic surveillance* applies to surveillance activities that use existing health-related data that are independent of a confirmed diagnosis and can signal a sufficient probability of risk to warrant further public health investigation. These data capture individual behaviours that occur following the onset of disease symptoms, such as absences from work or school, the purchase of over-the-counter (OTC) medication or calls to health telephone help lines. Preliminary contact with a health care provider, including sentinel community physicians and emergency departments (EDs), are also valuable sources of syndromic surveillance data.

One goal of syndromic surveillance is to detect clusters of syndromes such as ILI and other respiratory or gastrointestinal (GI) illness, beyond what would normally be expected in a certain population for a certain period of time. The perceived advantage of focusing on syndromes rather than on clinical or laboratory diagnoses is increased sensitivity: the ability to detect actual cases or outbreaks of a disease when they occur. However, this increase in sensitivity usually comes at the cost of decreased specificity: the ability to recognize when alerts are not related to specific disease events. If a syndromic surveillance system is highly sensitive but not very specific, it will repeatedly trigger public health authorities to false-positive signals, resulting in a waste of resources to investigate the alarm. Conversely, if a system is not sensitive enough, it will not alert public health authorities to significant events and will lose utility. Thus, the validity and perceived usefulness of a syndromic surveillance system relies on the ability to discern between true-positive and false-positive alerts found as a consequence of a system with high sensitivity but low specificity.

In the wake of the 2001 terrorist attacks in the United States and the subsequent anthrax outbreak, the development and use of syndromic surveillance data increased, initially as a tool to detect bioterrorism threats.[2] Since there has been no known bioterrorism attack since 2001, the evaluation of many syndromic surveillance systems now focuses on their utility beyond that of bioterrorism preparedness. In the last decade, public health agencies have utilized a variety of syndromic surveillance data sources to monitor infectious disease activity. In Ontario, daily calls to Telehealth are monitored provincially, and ED syndromic surveillance systems have been deployed in over 70 hospitals in 18 health units.[3,4] In addition, various other syndromic surveillance data sources, such as school absenteeism, are being monitored in several Ontario health units.[5]

The greatest perceived benefit of syndromic surveillance systems may be their posited ability to detect infectious disease outbreaks earlier than traditional systems. An additional benefit may be heightened situational awareness during outbreaks or periods of perceived elevated risk. Syndromic surveillance has been recognized as a tool that can signify the start and/or end of an influenza season; provide descriptions of the potential burden of disease beyond traditional methods; or provide reassurance of no effect during a state of perceived increased risk. There may be added benefit in using syndromic data in conjunction with traditional surveillance data or combining multiple syndromic data sources to monitor a given syndrome.

While the potential benefits of syndromic surveillance systems are documented in the scientific literature, there are costs associated with setting up such systems. It is necessary to determine whether detection methods based on syndromic data actually translate into earlier responses or other public health actions. While the value of syndromic surveillance is being evaluated around the world, its use is growing, especially in the wake of public health emergencies such as the recent H1N1 influenza pandemic, where situational awareness was crucial. As these systems expand, local public health departments are looking towards centralized support and standards for these systems.[6] It is therefore important to describe the types of syndromic surveillance data already in use, consider how they are being applied, and assess whether they are effective in achieving their intended purpose.

Methodology

Search methodology

A literature search of the electronic database MEDLINE was performed using the following search terms:

- Syndromic AND (Sentinel Surveillance[MeSH] OR Population Surveillance[MeSH:noexp] OR Surveillance[tiab] OR Models, Statistical[MeSH] OR Disease Outbreaks[MeSH] OR "Influenza A Virus, H1N1 Subtype"[MeSH]) AND "humans"[MeSH Terms]

Inclusion/exclusion criteria:

- Publication dates limited to January 1, 2003, to April 30, 2011
- English-language publications only
- Exclusion of literature pertaining to bioterrorism published in the wake of the September 11, 2001 terror attack
- Exclusion of publications identified as “letter” or “editorial”

Data collection and analysis

SELECTION OF STUDIES

The titles and abstracts of all studies identified by the search strategy were reviewed by members of the Provincial Infectious Diseases Advisory Committee on Surveillance (PIDAC-S) to ensure adherence to the inclusion and exclusion criteria. For example, non-infectious disease events (e.g. extreme heat, injury) were excluded. A study deemed to be relevant by at least one PIDAC-S member was subjected to further methodological assessment.

DATA EXTRACTION AND ANALYSIS

A quality assessment tool (QAT) was developed to permit an objective assessment of the studies determined to be of relevance and provide a measure of quality (the “score”) (Appendix 1). Articles were assessed and graded on six dimensions, for a maximum score of 35 points:

- Relevance to the Ontario context
- Study design
- Publication/peer review
- Economic assessment
- Data collection
- Data analysis

The QAT also allowed for the inclusion of a component representing the subjective opinion of the reviewer (the “grade”).

The QAT was validated prior to use via the assessment of 17 randomly selected studies by a pair of PIDAC-S reviewers and a third (trainee) reviewer. The validity of the tool was determined by the agreement between reviewers and was based solely on the overall scores assigned.

Following validation of the tool, all publications were reviewed independently by paired PIDAC-S reviewers; approximately equal numbers of publications were reviewed by each pair of reviewers. Studies retained for inclusion required a quality assessment score of >18 from at least one PIDAC-S reviewer and/or a subjective grade of "A" by at least one reviewer and/or a subjective grade of "B" by both reviewers.

A standardized, web-based data abstraction tool (Appendix 2) was developed in Fluid Survey and pilot tested by two PIDAC-S reviewers on two randomly selected studies and refined accordingly. Eight PIDAC-S members (five of whom reviewed the publications) extracted information from the included studies on: the data source, uses of the data, sensitivity/specificity, considerations for adopting syndromic surveillance, and recommendations and/or conclusions. All information was then exported to Microsoft Excel for analysis.

The abstraction process identified nine themes of syndromic surveillance data sources. Six PIDAC-S members involved in the review and/or data abstraction were assigned to one or more categories and asked to summarize relevant abstracted data using a standardized framework. This framework outlined five key areas for summary: potential uses of the data, described benefits, data or system limitations, circumstances or situations required to make the data source beneficial and whether the data source should be recommended for investment. To ensure a consistent approach to the summary of benefits and limitations, prompts were included on whether the data or system provided early warning of an aberrant event, if there was high sensitivity and/or specificity, if the early warning generated prompt action or earlier response, and whether there were cost benefit and/or resource implications. Each summary was presented at a PIDAC-S committee meeting where feedback was received; summaries were then revised as necessary.

Using the CDC evaluation framework[136] as a guide only, the same six PIDAC-S members who summarized abstracted data were asked to comment on whether the studies in each category described evidence of specific syndromic surveillance data characteristics. This assessment was performed to help support and inform recommendations and to identify gaps in the literature.

Results

Description of studies

The search strategy identified 320 potentially relevant studies. Following a review of titles and abstracts, 130 studies were excluded during the preliminary screening. The full-text versions of 190 studies were reviewed and scored, resulting in a further 65 being excluded based on the assigned score or grade. Next, 125 studies were abstracted, assigned to one or more of ten themes according to surveillance data source and summarized for inclusion in the report (Figure 1). A complete list of all 125 included studies by theme can be found in Table 1.

Just under half of the included articles were published in 2009 onwards (Figure 2). Articles most frequently originated from the United States (48%), followed by Australia (10%), Canada (9%) and the United Kingdom (9%). Over one third of articles (35%) described the use of emergency department chief complaints for syndromic surveillance (Figure 3 and Table 3). The second most frequently described syndromic data source was health records other than from emergency departments (20%), followed by telephone help lines (11%) and pharmacy sales (10%).

Any evidence of specific syndromic surveillance data characteristics found in the studies by the reviewer were captured in Table 2. There was sufficient evidence in the literature that timeliness was present for all data sources with the exception of sentinel community health care providers and pharmacy sales. Attributes of acceptability, simplicity, positive predictive value and sensitivity were also demonstrated for the majority of data sources (5/9). System flexibility and stability was not described for four and three data sources respectively. Examination of system attributes by data source revealed that there was only evidence of one attribute in the literature on emergency medical services (timeliness) and pharmacy sales (simplicity). Three attributes for employee absenteeism were demonstrated: simplicity, sensitivity and timeliness. By contrast, all other data sources demonstrated four or more of the nine attributes assessed.

Syndromic surveillance data sources

ABSENTEEISM: EMPLOYEE

Employee absenteeism as a source of syndromic surveillance data involves the monitoring of employees reporting an absence from their workplace—either all-cause or syndrome-specific absences.

- **Uses**

  Employee absenteeism data have been suggested as a useful source for the early detection of outbreaks or disease clusters and for identifying the start and end of seasonal pathogen circulation, such as influenza and norovirus.

- **Advantages**

  The main advantage attributed to the use of employee absenteeism for syndromic surveillance is the timeliness of the data. In the Netherlands, surveillance of employee absenteeism signalled the start of seasonal spread of respiratory syncytial virus (RSV) and influenza 2 and 4–5 weeks earlier than laboratory confirmation, respectively.[7,8]

- **Disadvantages**

  Numerous disadvantages are associated with employee absenteeism as a source of syndromic surveillance data, including the lack of readily available data. Available data are typically not cause-specific and may capture seasonal aspects of absenteeism that are not related to communicable disease activity.[8] Overall, employee absenteeism is a source of syndromic surveillance data with low specificity.

- **Recommendation**

  Given the scant evidence on employee absenteeism, an evaluation of its potential utility as a syndromic surveillance data source cannot be provided. Therefore, its adoption in Ontario is not recommended at this time.

ABSENTEEISM: SCHOOL

School absenteeism as a data source for syndromic surveillance involves the use of school records to identify student absence—either all-cause or syndrome-specific absences.

- **Uses**

  School absenteeism data have been shown to be effective in the early detection of outbreaks. Records of student absences can be helpful in contributing to the understanding of the epidemiology of influenza in the community setting by monitoring trends over time, and by identifying activity specific to a grade, school or district.[9] In pandemic situations, such as during the H1N1 pandemic, school absenteeism data have also been utilized to determine when influenza assessment centres should be opened, what to advise community providers and when an outbreak has terminated.[10]

- **Advantages**

  One advantage of syndromic surveillance systems utilizing school absenteeism data is improved timeliness and early detection. One system monitoring university student absenteeism in Canada detected an outbreak of influenza 1 week prior to other surveillance systems, as did a Japanese surveillance model based on student absenteeism.[10,11] School absenteeism has also been shown to correlate with other traditional data sources, such as laboratory confirmation of respiratory pathogens.[12]

  As a source of data for characterizing the epidemiology of disease in a targeted population, the advantages associated with school absenteeism records include the ability to combine the data with clinical information about student illness to inform decisions regarding disease control measures, suspension of classes, school closures and communication with parents.[9]
  If automated, monitoring of school absenteeism is a simple surveillance method that requires minimal human resources for maintenance and allows public health officials to use limited resources efficiently.[9] Automated self-reporting of illness and absenteeism in university students has also been shown to provide an opportunity to disseminate information about self-care and appropriate timing for return to school, as well as generate a medical note, thereby saving human resources.[10]

Given that some jurisdictions have a legal requirement to record student absences at the school level, data would be complete and a denominator of children at risk would be available, permitting the calculation of population-based prevalence rates.[12]

- **Disadvantages**

  Although reporting of school absenteeism may be mandatory in some areas, it may be inconsistent by some schools, participation may vary from week to week and the criteria for defining a student absence may differ.[9] A significant disadvantage is that data are not available for weekends and extended school holidays.[12]
  School absenteeism as a data source has low specificity, as schools do not routinely collect information on the reason for student absence.[9,12] Reacting to every signal would result in an unacceptable number of false positives and inefficient use of public health resources.[9]

- **Recommendation**

  If data collection and analysis are automated and consistent reporting by schools using common criteria for absences is encouraged provincially, an investment in school absenteeism as a syndromic surveillance data source would be recommended. In Ontario, the requirement for schools to record data on student absenteeism and report quarterly to the Ministry of Education provides a basic system that could be mined for syndromic surveillance purposes, although more frequent reporting would be required to make this a timely data source for syndromic surveillance. Cause-specific data for school absenteeism that differentiate between respiratory and GI illness would be ideal.

EMERGENCY DEPARTMENT CHIEF COMPLAINT

ED chief complaints are records of patient-reported signs and symptoms of illness at presentation.[13] Each chief complaint generally consists of a concise statement entered into an electronic system in short free-text phrases.[7]

- **Uses**

  ED chief complaint data have been used in the early detection of disease clusters or outbreaks,[14-17] and in the identification of the start or end of the season for pathogens such as influenza.[18,19] Surveillance systems based on ED chief complaint data have also been utilized during mass gatherings such as the Major League Baseball World Series, the Olympic Winter Games and NASCAR Winston Cup Series events[20,21]; in the identification and monitoring of novel threats such as anthrax utilized as a bioterrorism agent; and during public health emergencies such as severe acute respiratory syndrome (SARS).[22,23] During situations of heightened alert, ED data have also been used to provide public reassurance (e.g. after the terror attacks on September 11, 2001)[24], identify when ED services are being overwhelmed, inform the timely mobilization of public health interventions (e.g. the opening of mass influenza assessment centres during the H1N1 pandemic) and measure their impact.[14] ED chief complaint data can also be used to supplement surveillance data from other sources, such as sentinel physician consults and laboratory testing.[25]

- **Advantages**

  One of the main reported benefits of ED-based syndromic surveillance systems is the improved timeliness of the detection of outbreaks or events, as data are collected in real time, 24 hours a day, 7 days a week. Demographic data such as age and sex, as well as spatial analytics, have the potential to provide real-time epidemiological analysis. In simulation models, syndromic surveillance data detected 51 to 59 per cent of outbreaks before clinical case findings (mean detection benefit of 1 day), based on simulated laboratory cultures with a set specificity of 90 per cent.[22] In a retrospective comparison of ED chief complaint data with positive influenza laboratory results, a detection benefit of 3 days (5 year average; annual range 3 to 18 days) was reported.[17] The onset of seasonal activity for infectious diseases, specifically influenza, was also reported to be detected earlier as compared to other surveillance data sources.[18,19] For example, ED data flagged the start of influenza season 2 to 3 weeks earlier than Centers for Disease Control sentinel ILI consult data in 2 of 3 eligible years examined.[18] . Earlier detection of influenza activity was also found when ED chief complaint data were compared to sentinel physician reporting and laboratory results.[16] During the H1N1 pandemic, alerts based on ED data occurred 7 days prior to laboratory confirmation.[28] One study also noted the benefits of early detection of non-reportable respiratory infections such as RSV.[26] Another feature described was the ability for multiple hospitals to connect through a common database for real-time results.[27] The timeliness of ED systems could not be assessed in several other studies, as no outbreaks were detected to enable a comparison.[15,20,24]

While not abundant in the literature, several examples were described of how earlier detection led to an improved public health response. These actions included early detection of a cluster of meningococcemia, which enabled health department staff to deliver timely post-exposure prophylaxis to identified close contacts[29]; early alert to the medical community of community-wide increases in GI and respiratory illness consistent with seasonal pathogens[16] (e.g. norovirus, rotavirus and influenza); and timely mobilization of public health interventions during the H1N1 pandemic.[14] Earlier detection also assisted with the identification of priority populations for treatment (e.g. pregnant women, select age groups), development of modified laboratory testing algorithms that focused on high-risk groups, cancellation of elective surgeries and assessment of the severity of illness.[30]

Another advantage is that in the absence of laboratory confirmation, ED chief complaint data can be used to track transmission of diseases such as influenza, particularly in smaller, more isolated populations where the number of laboratory-confirmed cases is low.[25]

- **Disadvantages**

One disadvantage of ED-based syndromic surveillance systems is that not all patients visit an ED as their first step towards treatment. For example, a survey of initial behaviour during ILI found that only 3 per cent of respondents visited the ED as their first course of action; respondents were more likely to first purchase OTC medication (37 per cent) or miss work/school (30 per cent).[32] Therefore, ED data may not be as timely as other syndromic data sources, but it is more specific, which improves usefulness.

Another disadvantage is the method by which ED chief complaint data are captured. Data entry for ED chief complaints is often unstructured, in free-text format, which reduces opportunities for automation to improve timeliness and efficiency. Computer algorithms for the classification, normalization and cleaning of ED data have reported differing levels of success, but increasing structure poses maintenance issues.[29,33-38] This process is also hampered by the absence of national standards for the classification of ED chief complaints.[36] Without such standards, the probability that a given syndrome detects true cases can be variable. For example, one study reported that the positive predictive value (PPV) of case definitions of 13 syndromes ranged from 20 to 99.3 per cent when compared to medical records and subsequent hospitalizations; half of the definitions had a PPV over 90 per cent, while sepsis, neurological/meningitis and coma were below 50 per cent.[31]

The detection algorithms used and type of event can also impose challenges for ED syndromic surveillance. Buckeridge et al found that the ability of an ED chief complaint syndromic surveillance system to detect outbreaks or the start of a seasonal pathogen was reliant on the sensitivity and specificity of the system and the number of cases involved.[22]

Lastly, there was some literature on the economic implications of the use of ED syndromic surveillance, albeit limited. Significant start-up costs were described, along with widely varying annual expenditure estimates, ranging from $75,000 USD to $280,000 USD.[15,40-42] However, the more automated the system, the less labour-intensive and the lower the annual operating costs.

- **Comparison of ED chief complaint to hospital discharge data**

When compared to hospital discharge data, ED chief complaint data have a number of advantages and disadvantages for syndromic surveillance. ED chief complaint data have been shown to better capture illnesses for which non-specific symptoms are the most important feature, but they are less useful at tracking illnesses that can be identified after a brief ED clinical evaluation and testing (i.e. sepsis and neurological syndromes).[20,25,43] For example, syndromes such as gastroenteritis (where the signs, symptoms and exposure history provide immediate diagnostic implications) fit this surveillance system better than others such as hemorrhagic diarrhea (where symptoms are not evident and a more precise diagnosis is needed).[31] The level of agreement between ED chief complaint and discharge data varies by syndrome, with poorer correlation observed for GI syndrome (r=0.48).[20] Moderate agreement between the two data sources suggests frequent misclassification, which was more prevalent in paediatric cases or persons presenting with multiple symptoms.[19,20] ED chief complaint data are often available earlier than discharge data; one study reported that 89 per cent of ED chief complaints were available to the syndromic surveillance system within 24 hours, compared to only 12 per cent of visits with at least one diagnosis code.[44]

- **Recommendations**

Demonstrated benefits of ED chief complaint–based syndromic surveillance systems are evidenced in the literature, particularly their utility for early detection of outbreaks and seasonal pathogens. A few studies described the cost-effectiveness of these systems and whether earlier detection translated into more effective public health responses.
Recommendations to minimize costs include the automation of systems to decrease annual staff time spent monitoring the system and investigating alerts. As well, improving or optimizing detection algorithms for specific data sources to improve the balance of sensitivity and specificity could result in decreased time spent investigating false positives.[18,45,46]
To further improve the PPV and utility of ED chief complaint surveillance data, linkages to laboratory and radiographic results are recommended.[43, 44] Creating standards for how free-text chief complaints are captured and categorized into syndromes will similarly improve PPV. Additionally, the creation of a public health dashboard that allows for the visualization of ED visit trends, in conjunction with other data streams, would be a more practical and meaningful approach, and may help reduce ambiguity in results and permit linkage to public health response.[14,15]

If systems can be optimized to improve PPV, minimize cost and maximize influence on public health action, an investment in ED chief complaints as a data source for syndromic surveillance would be recommended.

EMERGENCY MEDICAL SERVICES, 911 CALLS AND EMERGENCY PREPAREDNESS

Syndromic surveillance data from emergency systems include assessment by emergency medical service (EMS) personnel, dispatch codes from 911 calls, and signs and symptoms recorded in response to patient calls to emergency services.[13]

- **Uses**

  Data from 911 calls and EMS first responders are most frequently used for surveillance during mass gatherings and to provide assistance during novel threats, emergencies or natural disasters. Surveillance data from these sources can be utilized to identify the start or end of circulation of a seasonal pathogen, provide early outbreak detection or describe the nature of an infectious illness.

- **Advantages**

  Agreement between EMS data and other syndromic surveillance data sources has been reported.[9,30] For example, ambulance dispatch data have been shown to demonstrate trends similar to sentinel ILI data during influenza season.[47] An enhanced surveillance system initiated as part of the emergency preparedness plan associated with the 2006 World Cup in Germany detected 77 per cent of infectious disease events related to the World Cup, compared to only 44 per cent detected by the routine surveillance system.[48]

- **Disadvantages**

  One study found that the use of ambulance dispatch data for ILI surveillance introduced some biases compared with surveillance of all ED visits: those who used EMS were older and more likely to complain of chest pain and shortness of breath.[49] Low sensitivity (58 per cent) and specificity (64 per cent) were also attributed to EMS and 911 calls as a data source in comparison to ED screening for ILI.[49]

- **Recommendation**

  A few articles were available regarding the use of 911 calls and EMS data for syndromic surveillance, but they were disparate in their description of the type of data collected, the use and analysis of the data, and the overall quality. As a result, this source of syndromic surveillance data cannot be recommended.

NON–EMERGENCY DEPARTMENT HEALTH RECORDS

Syndromic surveillance systems based on health records are usually coded using the International Classification of Diseases (ICD), which allows for the assignment of codes to diagnoses and procedures.[13] These data may be retrieved from a variety of sources, including visits to community physicians; military clinics, travel clinics, influenza clinics and women's groups; community physician billing data; health care management organizations; and health plan, hospital discharge and mortality data.

- **Uses**

  Syndromic surveillance systems utilizing data obtained from community sources beyond sentinel health care providers and EDs can be used for the early detection of disease transmission, the identification of outbreaks and the detection of the start of circulation of seasonal pathogens. Syndromic surveillance data obtained from community health care sources can complement other surveillance data by providing an assessment of illnesses that do not require hospital admission or identification of an etiologic agent and demonstrate the extent of an outbreak beyond cases identified through laboratory confirmation.[50,51] Epidemiologically significant information, including the burden of disease and identification of shifts in virulence, can be identified by monitoring surveillance trends from hospitalization and mortality data.[30,52] The increased level of information available when syndromic surveillance data are obtained from a variety of community health care sources can be used in planning the diagnostic capacity required for testing symptomatic persons.[52]

A surveillance system that incorporates reporting from community health care sources can facilitate communication with the public and provide reassurance by quantifying the effect of disease transmission on the population, including mortality, and it can prevent unnecessary precautions from being taken.[53]

- **Advantages**

Early detection of a number of outbreaks has been reported in the literature, including a retrospective review of hospital data for lower respiratory tract infections that identified an outbreak of Legionnaires' disease 4 days earlier.[121] Similarly, a retrospective investigation of lower respiratory tract infections, hepatitis and/or endocarditis in hospital medical records detected clusters of disease that could be plausibly attributed to unrecognized Q fever before the first known outbreak was reported.[52] Syndromic surveillance data from military health care providers triggered the declaration of a dengue fever outbreak 3 to 4 weeks prior to laboratory confirmation.[54] Review of physician billing claims has also demonstrated that visits to outpatient clinics for ILI tend to increase in frequency up to 2 weeks earlier than visits to EDs.[55]

Monitoring syndromic surveillance data obtained from community health care sources can also assist in the identification of the start of influenza season (at least 1 week earlier in 5 out of 6 influenza seasons in Ireland) or pandemic events (detection of an increase in community H1N1 1 week earlier) and indicate when the management strategy for controlling disease transmission should be enhanced or altered.[56-58]

The quantity of data available is increased with the use of a surveillance system that includes health records and a variety of community health care sources. Hospital ED data are reflective of the more severe cases of disease, and surveillance limited to this level may miss cases that are not severe enough to warrant laboratory testing or a hospital visit.[50,56] Syndromic surveillance data obtained from community health records may also identify disease transmission earlier, as those in the early stages of illness may exhibit milder symptoms that require community-based rather than ED care.[55] In some settings, depending on the organization of the health care system, primary care physicians may act as the patient's first contact or "gatekeeper" and may therefore be able to provide the earliest case report.[59] Complete health data records, as opposed to a reporting of only the chief complaint or discharge diagnosis, may also provide additional information pertinent to the investigation of disease transmission, such as duration of symptoms or travel history.[60] The greater availability of postal codes may improve geographic accuracy and spatial analysis of disease activity, which is critical for tracking the spread of disease and identifying "hotspots" of community transmission.[50,56,61]

- **Disadvantages**

A number of limitations are associated with syndromic surveillance data from non-ED community sources and health data records. No system is currently available to continuously monitor medical records from community health care providers in real time in Ontario.

Information may be more easily obtained from other surveillance systems, such as those using ED data.[55]

The ability of community health care providers to capture cases is limited by disease presentation: those with severe symptoms are more likely to visit an ED, while those with milder, self-limiting symptoms are less likely to seek medical advice; therefore, the ability to detect an outbreak is diminished.[62,63] The number of participating community health care providers must be large enough and have sufficient geographic coverage to have a high degree of sensitivity for disease detection; they must also be representative of the whole population while providing reliable information at the local level.[7,50]

The accuracy of syndromic surveillance data obtained from health records and community health care providers can vary. The lack of data standards and differences in the coding of symptoms and diagnoses by physicians and hospitals, as well as coding errors, can result in false alarms or repression of signals of disease transmission.[7,50,62,63] Although health data records provide a greater quantity of surveillance data, the usefulness of the data for describing the epidemiology of a disease and tracking the spread of an outbreak can be questionable (e.g. the relevance of a case patient's home postal code for spatial analysis as opposed to the location of his/her workplace).[62,63] Similar to other syndromic surveillance systems, data obtained from health records and community health care providers is sensitive to outside influences, such as increased publicity surrounding infectious disease activity and public health recommendations to seek health care.[51,56]

- **Recommendation**

The increased use of electronic medical records (EMRs) by community health care providers could provide an extensive and timely data source for syndromic surveillance, but would likely be associated with initial organizational and ongoing administrative costs. Data linkage and the use of multiple data sources for syndromic surveillance would allow for the coverage of the spectrum of disease morbidity from mild to severe, but sufficient information must be available to effectively verify signals.[7] As with other syndromic surveillance systems, data standards and common definitions would be required. Although not recommended for immediate use, it is recommended that the adoption of EMR systems by physicians in the province be monitored and opportunities to leverage this type of syndromic surveillance data be investigated when EMR systems are more fully implemented.

ONLINE RESOURCES

Syndromic surveillance systems based on online data utilize information obtained from the monitoring of online search trends and Internet-based self-reporting illness tools. Analysis of online search trends provides an estimate of disease activity via the aggregation of search engine queries and demands for health information (e.g. Google Flu Trends).

- **Uses**

The primary use of syndromic surveillance data from online data sources has been early warning of disease transmission and outbreak detection.[10,64] Internet-based data can also be used to signify the start or end of transmission of seasonal pathogens.[65] Online data sources have also been used to provide situational awareness, aid in the epidemiologic description of a disease and perform surveillance during a mass gathering such as the G8 summit.[66]

- **Advantages**

  One advantage of syndromic surveillance data obtained from online resources is earlier detection of infectious disease activity. In Canada and the United States, online resources have detected influenza activity 7 to 10 days earlier as compared to surveillance systems that rely on laboratory confirmation of ILI.[64,67] An Internet self-reporting system for influenza in Australia demonstrated an ability to detect the peak in influenza activity that coincided with traditional syndromic and laboratory-based surveillance.[65]

  Syndromic surveillance systems relying on online data sources are most useful in geographic areas where Internet access is readily available and among populations where Internet use is prevalent. In these settings, online data sources can complement traditional surveillance systems and laboratory data. Search trends for health information are highly correlated with ILI surveillance in Canada (r=0.91), Sweden (r=0.89 to 0.90) and Europe (r=0.72 to 0.94).[67,68,69] The operational costs for surveillance systems that collect data from online sources can be low, and these systems have the ability to track illness in real time. Furthermore, this source of data captures information on those who may not otherwise seek medical attention. Additionally, the completeness of online tools for the self-reporting of illness may exceed that of more traditional methods, such as phone reporting directly to public health departments.[70]

- **Disadvantages**

  The relevance of online syndromic surveillance data collected by tracking influenza-related online searches can be influenced by sex (female), age and search trends.[67] Also, Internet usage may be decreased during illness. Generally, geographic data from online sources can be analyzed only at a national level, as opposed to local information on disease transmission, unless Internet service provider–specific information is collected.[67]

- **Recommendation**

  Online resources remain in their adolescence as a tool for syndromic surveillance, and the current evidence does not provide collective support for any particular aspect of online surveillance. Monitoring of online search trends and the use of online self-reporting illness tools appear to have potential for supporting and enhancing traditional syndromic surveillance systems, but at this time they would be limited to national monitoring. Additional evidence is required focusing on ease and equity of access to the Internet, methods to entice people to self-report illness online and the cost-effectiveness of an Internet-based surveillance system. At the current time, a moderate investment in this type of surveillance would be recommended until the Internet is more representative and accessible, and until better geo-locator information accompanies these data.

PHARMACY SALES

Syndromic surveillance systems utilizing pharmacy sales monitor the dispensing of OTC and/or prescription medications that are used to treat certain illnesses or syndromes such as ILI or GI illness.[13]

- **Uses**

  Syndromic surveillance systems based on pharmacy sales have been used in the early detection of outbreaks,[7,8,75,71,99,125-127] the identification of the start of a pathogen's seasonal transmission in routine surveillance programs,[72,74] and health-system planning and disease burden assessment during emergencies.[85]

- **Advantages**

  Pharmacy sales data can be rapidly transferred to public health authorities, leading to more timely alerts and potential gains in lead time for outbreak response. Pharmacy sales data have been shown to be congruent with other syndromic surveillance data sources. In comparison to physician insurance claims, peaks in OTC sales of influenza remedies occurred 2.8 days earlier than patient-physician encounters.[71] The incidence of ILI based on sentinel general practice physicians has also been shown to correlate well with pharmacy sales (r=0.85–0.96), as has physician diagnosis of acute respiratory conditions and OTC sales of influenza remedies.[72,73] For GI illnesses, the temporal patterns of OTC sales of diarrheal remedies were most closely related to laboratory-confirmed norovirus infection (r=0.44).[74]

- **Disadvantages**

  The usefulness of pharmaceutical sales as a syndromic surveillance source appeared to differ based on the type of infectious syndrome. Several studies reported early detection of respiratory outbreaks and high correlation with the diagnosis of respiratory infection, but the sales records for OTC diarrhea remedy sales had a sensitivity of only 4–14 per cent in the detection of GI outbreaks and individual cases.[75]

  The specificity of surveillance systems utilizing data from pharmacy sales is low and is influenced by seasonal trends, retail sales and the location of purchase. Prescription sales data are likely more specific than OTC sales, although this does not account for off-label use for multiple conditions. Misleading clustering may be reported based on purchasing trends that reflect locations other than the customers' place of residence.[75]

  Little assessment is available as to the cost/benefits or resource requirements of syndromic surveillance systems that employ pharmacy sales data.

- **Recommendation**

  Investment in pharmacy-based syndromic surveillance systems is not recommended at this time, as the evidence of the timeliness of the data, the sensitivity and specificity of the system and the economic costs are not well established. Pharmacy sales data could be a useful source of syndromic surveillance data if combined with clinical and/or demographic data to further characterize cases, and if used in conjunction with other traditional surveillance data sources to detect concurrent signals. Further research is required to determine appropriate public health responses to detected alerts from pharmacy sales and assess public health significance.

SENTINEL COMMUNITY HEALTH CARE PROVIDERS

A syndromic surveillance system based on sentinel community health care providers involves monitoring and analyzing counts or rates of new cases of illness identified during the routine delivery of health care by primary care practitioners (physicians and nurse practitioners) who volunteer to be part of a surveillance network.[62] Electronic medical records from primary care practitioners and outpatient clinics may be utilized.

- **Uses**

  Surveillance data from sentinel community health care providers may increase situational awareness and have been shown to be of use in the monitoring of trends in disease transmission and early identification of outbreaks of infectious diseases.[8,76] In simulation models, data on ILI from sentinel health care providers have demonstrated the ability to detect large-scale outbreaks (i.e. pandemics).[76]

- **Advantages**

Sentinel community health care providers as a source of syndromic surveillance data may provide data on a large number of people, in real time, if EMRs can be assessed.[62] In terms of human resources and financial costs, the maintenance of a sentinel health care provider syndromic surveillance system for ILI is inexpensive, although resources are required for the initial system development and ongoing recruitment of health care providers.[77]

- **Disadvantages**

If access to EMRs is not available, receipt of surveillance data from sentinel community health care providers is not timely, although this may be improved with the use of automated data submission, including Web-based reporting.[77]

Those not ill enough to seek medical attention will be missed. A level of extra alertness by clinicians may render the data unreliable for surveillance purposes. The quality of surveillance data obtained from sentinel community health care providers may also vary by patient age. For example, the elderly, who are more likely to experience severe ILI symptoms, may bypass their community health care provider and visit the hospital directly, resulting in an inaccurate assessment of disease burden in this age group.[8] The value of surveillance data from sentinel community health care providers may also vary by specific respiratory virus, with the monitoring of the circulation of certain viruses (i.e. influenza A and B, RSV) being superior to others.[8] Syndromic surveillance systems based on data from community health care providers are associated with low sensitivity, even when a standardized case definition is utilized.[62,77] Attempts to increase the sensitivity of the surveillance system may compromise the specificity, although this can be ameliorated by encouraging community health care providers to obtain specimens for respiratory viruses from symptomatic patients and combining the resulting reports of laboratory-confirmed influenza with sentinel syndromic surveillance data.[77]

- **Recommendation**

Based on the available evidence, sentinel community health care providers as a source of syndromic surveillance data would be recommended at a provincial level for ILI, assuming the availability of a common electronic system with common definitions and data standards. A similar system would not be recommended for use at the local level, as the small number of sentinel health care providers would result in unstable rates of disease (although this would be dependent on the geographic coverage of sentinel sites). The use of EMRs should be investigated further, after data-mining issues (e.g. case definitions, data entry discipline, automated data export analysis) are resolved. The incorporation of sentinel EDs reporting surveillance data specific to non-admitted patients may enhance the syndromic surveillance system, as EDs are representative of the community, provide year-round 24/7 access and are staffed by health care workers familiar with obtaining specimens for respiratory viruses.

TELEPHONE HELP LINES

Telephone help lines are services where the general public can access a qualified health professional at any time to receive health advice or general health information via telephone. Most help lines collect demographic information, assess symptoms and provide advice on what additional health care should be sought. The degree of integration with the health care system differs between countries.

- **Uses**

Syndromic surveillance data obtained from telephone help lines can be utilized in the detection of outbreaks and early warning of disease clusters, as well as identifying the start of seasonal pathogen detection (e.g. influenza). Once infectious disease transmission has been reported, telephone help lines can also be useful in tracking the spread of disease and identifying the areas affected. During the H1N1 influenza pandemic, the deputizing service in Australia was able to confirm the peak of ILI in various areas. Analysis of calls to the United Kingdom's National Health Service (NHS) Direct line was able to assist in the identification of the geographic boundaries of a cryptosporidium outbreak.[51,78]

- **Advantages**

Syndromic surveillance systems based on data from telephone help lines may detect outbreaks and infectious disease transmission in advance of other data sources. Ontario's Telehealth system detected the peak in the influenza season 2 weeks earlier in the 2004–2005 season and 1 week earlier in 2005–2006 season, compared to official laboratory-based reports from the Public Health Agency of Canada.[27] Retrospective review of NHS Direct surveillance data identified seasonal influenza activity 2 weeks in advance of general practitioner (GP) consultation data in 3 of 4 seasons and 6 days' advance warning in a prospective evaluation in the 2006–2007 influenza season.[79] Similarly, Ireland's Out of Office Hours automated GP consultation service detected a peak in influenza-related calls 1 week prior to the national ILI consultation data.[57] Prospectively, in 2009, calls to NHS Direct exhibited an increase in H1N1 activity 1 week prior to GP consultation data, and these data informed public health professionals about the degree of community transmission, resulting in the move from the containment to the mitigation phase of the pandemic response.[56] Similar advance warning was not identified for GI illness, although 2009 Ontario Telehealth data documented an increase in GI illness–related calls simultaneously with ED visits.[80]

Syndromic surveillance data from telephone help lines also fill a gap left by other surveillance sources. Telephone help lines are generally available for long periods of time (e.g. Telehealth is available 24 hours a day, 365 days a year) when GP offices are closed, and although emergency room data would identify cases during evenings, weekends and holidays, these cases are likely to be only those of severe illness.[57,81] Telephone help lines may be particularly useful when a predominating influenza strain does not initially cause significant levels of illness, so that neither GP nor ED data would capture meaningful information.[82] Telephone help line data may also permit improved surveillance in underserviced areas such as northern Ontario, communities that are not integrated with routine surveillance systems (such as First Nations communities) and areas with limited access to emergency facilities and family physicians.[81]

The potential for the linkage of demographic information from calls to telephone help lines would improve geographic accuracy and allow for spatial analysis of disease transmission. For example, data from NHS Direct were used to map the geographic spread of the H1N1 outbreak in the U.K. in order to monitor transmission.[56,57]

- **Disadvantages**

Poor population representation is one limitation of syndromic surveillance systems based on data from telephone help lines. If the system is not centralized, patterns of use will not be equal in a population and thus not representative on a national scale.[62] The Out of Office System in Ireland is a voluntary subscription service for GPs, so not all physician practices are associated,

and therefore patients of practices not affiliated with the system are not represented.[57,78] There is an age and sex bias seen in both the U.K. NHS Direct and Ontario systems. The highest call rates are related to young children and are lowest for those over 65 years of age.[81-83] In addition, women are more likely than men to use these systems.[81-83]
The accuracy of information obtained via telephone help lines is also questionable. Cases of illness captured by help line systems are self-reported and thus not as reliable as traditional laboratory-based methods or physician assessment of clinical syndromes.[57] The volume of calls to a telephone help line is also likely influenced in circumstances where there is publicity surrounding an incident.[51] A non-specific case definition may also capture cases that are not related to each other in any meaningful way.[51,57]

- **Recommendations**

Syndromic surveillance utilizing telephone help lines could be improved with the addition of a clear and working link between those administering the telephone help line and those analyzing the data for potential public health action. This would assure a systematic and consistent approach to how this data source would inform when public health action should be taken.[57,83] The inclusion of spatio-temporal analysis would help identify subregional variation of disease rates.[51]

Given the availability of data in Ontario (Telehealth), the use of telephone help lines for syndromic surveillance would be recommended. There appears to be great potential to use this source of information in a meaningful way, especially in the early identification of widespread acute illnesses, such as influenza. However, telephone help line surveillance requires more evaluation and statistical validation. Benefitting from the Ontario Telehealth system will also require a centralized approach in an overall surveillance strategy that provides recommendations for its use at the provincial and local levels.

Discussion

Limitations

There were limitations identified in the search strategy utilized. The source material was limited to findings published in peer-reviewed scientific literature; reports in the grey literature and unpublished research known to the committee were excluded. As a result, much of the existing information pertaining to the use of syndromic surveillance in Ontario was not included. Other research on systems based in Ontario and Canada as a whole did not meet the scoring/grading quality criteria. As the literature regarding syndromic surveillance in Canada was limited, the applicability of data from other jurisdictions needs to be taken into account; those locations with a similar health care system would be the most generalizable to the Ontario setting.

In addition to the absence of material specific to Ontario, the available literature was also limited for certain syndromic surveillance data sources, thus hampering the ability to make informed recommendations. The majority of the literature that met the inclusion criteria examined infectious disease detection capabilities through retrospective or mathematical model-based approaches that limited the ability to assess the utilization of syndromic surveillance to prospectively inform public health action. Finally, very few of the papers reviewed described the cost benefits of syndromic surveillance related to public health intervention and public health significance, making it difficult to evaluate the data sources in this context.

Overall recommendations

PIDAC-S recommends the following regarding syndromic surveillance data sources for Ontario (summarized in Table 3). Sentinel community health care providers, telephone help lines and ED chief complaint are already in use as sources of syndromic surveillance data in Ontario, and their continued use is recommended with ongoing evaluation, validation and cost-benefit analysis.

Infrastructure and reporting strategies are in place across the province for the reporting of ILI by sentinel community health care providers, and with the exception of ongoing recruitment, the maintenance of the system is not difficult or costly. The timeliness of the data may be an issue, as submission is currently done on a weekly basis, delaying analysis. In addition, although data provided by sentinel community health care providers are a valuable resource for surveillance at the provincial level, the number of sentinels and their geographic distribution prevent data interpretation at the local level. Recruitment of additional sentinel sites may increase the applicability and acceptability of this form of syndromic surveillance to public health at the local level.

Telehealth Ontario collects a large volume of data, categorizes calls based on specific symptom-based criteria and has an existing reporting structure. Monitoring for significant changes in the volume of calls due to a syndrome of interest (e.g. ILI) allows for the possible early detection of outbreaks or clusters of infectious diseases and the quantification of the burden of disease; the collection of postal code data permits geographic analysis of disease transmission. Daily monitoring of Telehealth calls for several years has so far demonstrated utility only in identifying the start of respiratory infection season. It is recommended that work continue on improving the quality and validation of Telehealth data.

ED chief complaint as a source of syndromic surveillance data was best documented in the literature, including Ontario examples supporting its utilization. The Emergency Department Syndromic Surveillance (EDSS) system currently monitors ED visits and all admissions to hospitals, together with severity of illness indicators and demographic data. The EDSS operates in 70 hospitals in 18 public health units across Ontario. The system generates alerts only to the local public health units of participating hospitals. The EDSS can take advantage of data sources with existing multipurpose capabilities: health system utilization; acuity and demographic assessment; acute and chronic disease surveillance; and modelling. Despite the quantity of published reports on ED chief complaint as a syndromic surveillance data source, the published literature related to the cost-effectiveness of such a voluntary system and the current impact of its use on public health response remains limited. Also at issue are the use of free text and the lack of standards in data entry. The ongoing refinement of natural language processing algorithms will assist in the resolution of this problem.

Standardized student absenteeism syndromic surveillance is not currently in place provincially, but information on student absence (overall, cause-specific or both) is routinely collected by schools and used by some health units. Therefore this would be a readily available, sensitive and timely data source if an automated system were developed for the consistent reporting of student absenteeism to public health units province-wide.

Online resources are considered to be promising syndromic surveillance data sources for the future. They would complement other data sources and provide information on those who may not otherwise seek medical attention. Local Ontario initiatives such as Brock University's "Got Flu" channel have reported early detection of outbreaks in a cost-effective and timely manner. Online resources have the capacity for geo-locating, but this is currently limited to the national level. Social media sites as a source for syndromic surveillance data also require further investigation.

The ability to utilize non-ED health records as a source of syndromic surveillance data is likely to increase as the number of community physicians using EMRs increases. EMRs would provide an extensive and timely data source, but the data collected would probably overlap with that reported by sentinel community health care providers and investigation would be required into how these two systems might be integrated.

Syndromic surveillance systems based on data obtained from EMS, pharmacy sales and employee absenteeism are not recommended for implementation in Ontario. There was limited literature available pertaining to each of these data sources, and strong evidence supporting their use was not provided. Their benefit for syndromic surveillance may be improved if combined with other sources of clinical or demographic data, but much of the data captured are also available from other, pre-existing systems.

The presented evidence of effectiveness and accompanying recommendations for the use of syndromic surveillance in Ontario is just one set of factors to take into consideration when determining the most appropriate syndromic surveillance data sources for the province. The syndromic surveillance systems already being utilized in Ontario need to be evaluated and the findings disseminated. In addition, existing data sources that are not currently being mined for syndromic surveillance need to be assessed to determine how they might be utilized or leveraged, and if accessing these data sources would add value. A thorough review of existing syndromic surveillance systems and additional data sources would require evaluation of the quality of the data available, the usefulness for surveillance and a cost/benefit analysis in the Ontario context. If new data sources are to be incorporated into Ontario's surveillance strategy, consideration must be given to how they will complement or enhance existing syndromic and traditional data sources, and what value would be added. The implementation of a syndromic surveillance system must consider the infrastructure and resources required to respond to signals generated by the surveillance data collected. This includes the requirement to analyze and interpret the data, the cost of investigating and responding to alerts, the liability associated with failure to respond, and the method of providing feedback to those with the ability to affect change and implement appropriate public health interventions.

Tables and Figures

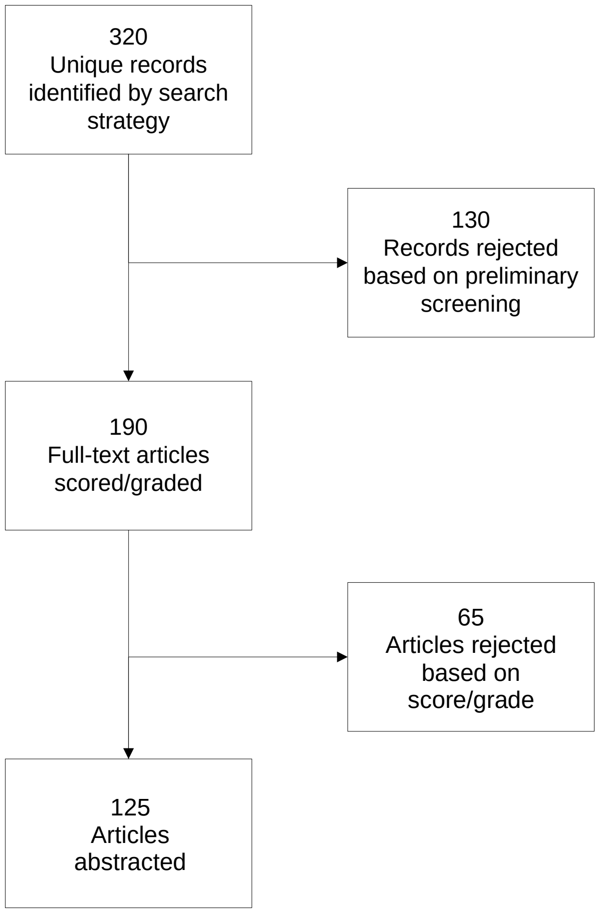

Figure 1: Flowchart of Study Selection Process

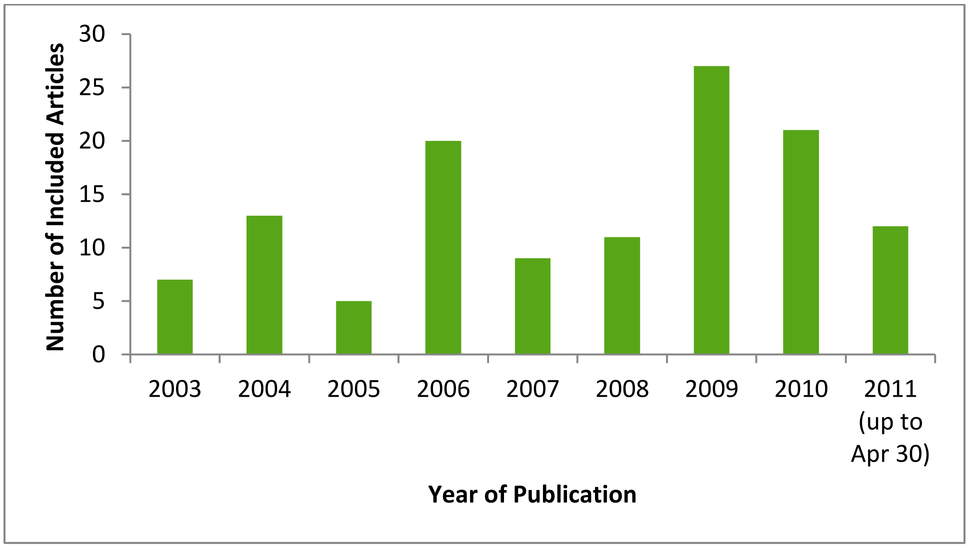

Figure 2: Frequency of included articles by publication year, N=125.

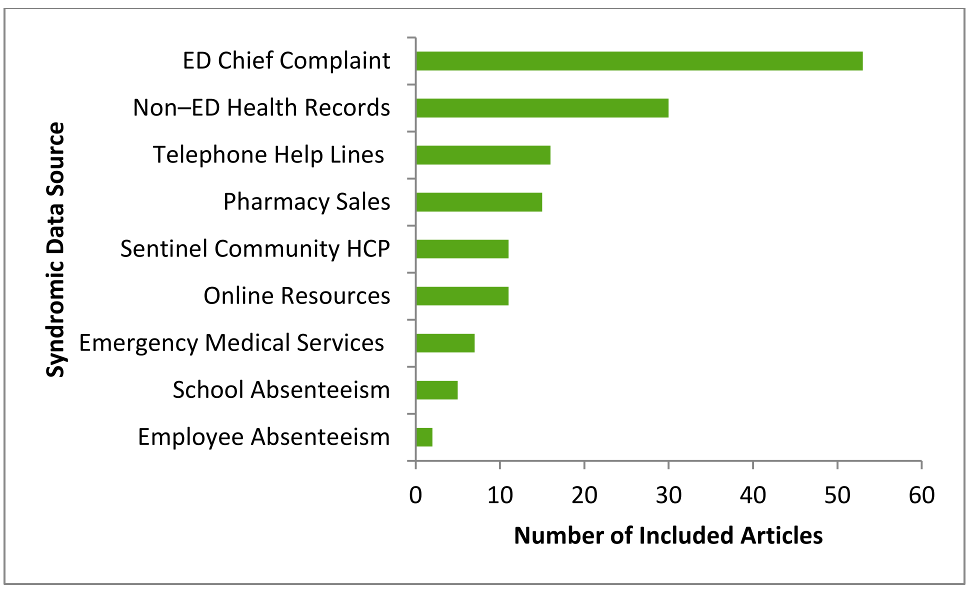

Figure 3: Frequency of included articles by syndromic data source described, N=150.*

*ED, emergency department; HCP, health care provider. *20 publications described more than one data source, therefore, the number of articles totals to 150, not 125.*

TABLE 1: DESCRIPTION OF INCLUDED STUDIES

Reference	Country	Study Period	Use	Intervention	Outcome
Absenteeism: Employee					
Marx et al. Am J Public Health 2006[85]	United States	Aug 16–18, 2003	Assistance during novel threats/emergencies/ natural disasters	Description of the detection of risk factors for diarrheal illness during a power outage	No analysis
Van den Wijngaard et al. Euro Surveill 2011[7]	Netherlands	2002–2003	Early warning/outbreak detection Monitoring disease burden	Syndromic surveillance data compared to laboratory-confirmed respiratory pathogens	Winter peaks concurrent with peaks in influenza virus, RSV and other respiratory pathogens 68% of variations explained by respiratory pathogens Alert 2 weeks ahead of RSV, 4–5 weeks ahead of influenza

Reference	Country	Study Period	Use	Intervention	Outcome
Absenteeism: School					
Baer et al. J Public Health Manag Pract 2011[9]	United States	2008–2009	Situational awareness	Description of an automated school absenteeism surveillance system: daily aggregate count of the number of students enrolled and absent stratified by school district, name and grade	No analysis
Jaeger et al. J Am Coll Health 2011[10]	Canada	2009	Early warning/outbreak detection	Comparison of Brock University "Got Flu" channel (student online self-reporting) to local primary and secondary school daily absenteeism	Outbreak detected >1 week earlier
Mann et al. Emerg Infect Dis 2011[84]	United States	Sept 8–Oct 21, 2009	Early warning/outbreak detection	Description of an automatic alert system generated for absenteeism rates >8% and when % absent was at least 1 SD above the 30-day mean	Reduction in false alarms
Schmidt et al. Euro Surveill 2010[12]	United Kingdom	2005–2007	Early warning/outbreak detection	School absenteeism compared to Influenza surveillance data from the Health Protection Agency (U.K.)	School absence correlated with influenza laboratory reports. Prevalence (all absences recorded on that day), correlation coefficient 0.52, p<0.001. Incidence (new absences that day) correlation coefficient 0.25, p<0.001.
Tango et al. Biometrics 2011[11]	Japan	2006	Early warning/outbreak detection	Description of the use of spatial scan statistics adapted to compare observed to the "conditional expected" count while accounting for time to time variation	Outbreak detected 7 days earlier

Reference	Country	Study Period	Use	Intervention	Outcome
Emergency Department Chief Complaint					
Ansaldi et al. J Prev Med Hyg 2008[86]	Italy	2007–2008	Early warning/outbreak detection	Comparison of ED chief complaint to influenza surveillance network and regional reference laboratory data	Alerting parameters used a 5-day moving average of 1.6 cases per day, resulting in a sensitivity and specificity of 72.9% and 90.3%, respectively Alert 2.5 days earlier
Baer. J Public Health Manag Pract 2011[9]	United States	Dec 15–24, 2006	Surveillances during a mass gathering/unique event	Comparison of EMS assessment for carbon monoxide poisoning to ED chief complaint during a power outage	79% cases were exactly identified in the syndromic data, 8% were likely matches, 6% were possible matches and 8% could not be matched
Begier et al. Emerg Infect Dis 2003[43]	United States	Dec 2001	Situational awareness	Comparison of ED chief complaint to discharge diagnosis	Good agreement between data sources (kappa=0.639), with variability by syndrome
Bellazzini et al. Am J Emerg Med 2011[28]	United States	2008–2009	Early warning/outbreak detection	Comparison of detection of ILI by ED syndromic surveillance and laboratory confirmation	ILI alerts from ED data occurred 7 days prior to first confirmed cases of H1N1
Buckeridge et al. Emerg Infect Dis 2006[22]	United States	2006	Early warning/outbreak detection	Development of a model comparing identification of anthrax via ED chief complaint with simulated clinical case finding (positive blood cultures)	When specificity was set at 90%, syndromic surveillance detected 51–59% of outbreaks before clinical case finding: the mean detection benefit was 1.0–1.1 days. When specificity was set at 97.5%, syndromic surveillance detected 19–28% of outbreaks before clinical case finding: the mean detection benefit was about 8 hours A specificity of 90% resulted in 1 false alarm every 10 days, while a specificity of 97.5% resulted in 1 false alarm every 40 days

Reference	Country	Study Period	Use	Intervention	Outcome
Burr et al. BMC Medical Inform Decis Mak 2006[87]	United States	1994–2003	Signify start/end of seasonal pathogen	Real and synthetic data (where there was not sufficient historical information) to evaluate if each year's seasonal peak had the same onset, duration and magnitude	No analysis
Chan et al. PLoS One 2010[88]	Taiwan	2006–2008	Early warning/outbreak detection	Development of a model for influenza surveillance and validated with historical ILI data	Model able to detect signals 1–2 days prior to the rise in ILI visits
Choi et al. BMC Public Health 2010[89]	Hong Kong	Sep 12–Oct 14, 2005	Early warning/outbreak detection	Description of a system for investigating the geographic distribution of ILI cases based on demographic data, provisional diagnosis, temperature at presentation to ED and residential location	40 case clusters detected: 25 had 2 or more patients living in the same building block, 18 were from residential care homes for elderly
Craigmile et al. BMC Med Inform Decis Mak 2007[45]	United States	2003–2004	Early warning/outbreak detection	Development of a statistical model for outbreak detection based on ED visit counts and chest radiography Evaluation of the model in detecting a simulated anthrax attack	No analysis
Dafni et al. MMWR Morb Mort Wkly Rep 2004[46]	Greece	2002–2003	Surveillance during a mass gathering/unique event	Evaluation of an aberration detection method (Pulsar) using surveillance data of ED chief complaint and comparison to other simulation approaches	Sensitivity higher than other methods (p<0.001)

Reference	Country	Study Period	Use	Intervention	Outcome
Das et al. J Urban Health 2003[24]	United States	2001	Early warning/outbreak detection	Description of a system implemented following Sept 11, 2001, to ensure early recognition of an increase or clustering of disease and based on data collected at ED, translated into syndromes and analyzed for aberrations in space and time within 24 hours	No outbreaks detected Citywide temporal alarms occurred 8 times for 3 bioterrorism-related syndromes Spatial clustering alarms occurred 16 times
Day et al. Ann Emerg Med 2004[33]	United States	2003-4	Systems evaluation	Description of the use of computer algorithms to classify free-text ED chief complaints into reason-for-visit categories	20 categories mapped to 77% of all patient visits in database 1 and 67% in database 2
Fan. Can J Public Health 2010[14]	Canada	2009	Early warning/outbreak detection Situational awareness	Comparison of Alberta Real Time Syndromic Surveillance Net (including calls to Health Link Alberta) to traditional paper-based surveillance methods	No analysis
Fleischauser et al. Acad Emerg Med 2004[20]	United States	Oct–Nov 2001	Surveillance during a mass gathering/unique event	Comparison of a surveillance system in which trained hospital care providers completed a surveillance form on all patients presenting to the ED to capture whether an event was attended (Major League Baseball World Series and NASCAR Winston Cup Series) and their primary condition to ED chief complaint and ED discharge diagnosis	No outbreaks detected Level of agreement was higher with ED discharge diagnoses (K=0.55) for all syndromes except GI relative to ED chief complaints (K=0.48)

Reference	Country	Study Period	Use	Intervention	Outcome
Foldy et al. J Public Health Manag Pract 2004[15]	United States	Jun 25–Jul 22, 2002	Early warning/outbreak detection	Description of a syndromic surveillance system based on ED chief complaint in addition to lab reports, hospital ED diversions, medical examiner reports, poison control and nursing hotline call volumes to detect outbreaks	No outbreaks detected
Gangnon et al. WMJ 2009[90]	United States	2007–2008	Early warning/outbreak detection	Comparison of ED chief complaint (fever and ILI) to ICD-9 discharge codes	True detection rates were substantially higher for methods based on longer baseline periods
Gesteland et al. J Am Med Inform Assoc 2003[21]	United States	Feb 8–Mar 16, 2002	Early warning/outbreak detection Surveillance during a mass gathering/unique event	Description of the implementation of a surveillance system during the Olympic Winter Games that compared current counts to expected counts computed by the system from historic data and triggered when current exceeded 95% CI of predicted	No outbreaks detected
Griffin et al. BMC Public Health 2009[18]	United States	2002–2006	Signify start/end of seasonal pathogen	Comparison of ED chief complaint to sentinel physician data (proportion of patients with ILI)	26 days earlier in 2002 and 20 days earlier in 2005; ambiguous in 2003 and 2006; same time in 2004
Guasticchi et al. Epidemiol Infect 2009[31]	Italy	2004	System evaluation	Evaluation of case definitions of 13 syndromes in a surveillance system based on an ED online database Comparison to subsequent hospitalization	PPV ranged from 20–99.3%. Sensitivity ranged from 22–90%

Reference	Country	Study Period	Use	Intervention	Outcome
Hafen et al. BMC Med Inform Decis Mak 2009[91]	United States	2004–2008	Early warning/ outbreak detection	Comparison of a new simulation model method (STL) to 4 known methods for detection of ILI and gastroenteritis outbreaks	STL out performed all other methods by 10% STL required only 90 days of historical data
Heffernan et al. Emerg Infect Dis 2004[16]	United States	2001–2002	Signify start/end of seasonal pathogen	Comparison of ED chief complaint to influenza laboratory isolates and sentinel physician reporting	Influenza season detected 2 weeks earlier than laboratory data and 3 weeks earlier than sentinel physicians
Hope et al. Commun Dis Intell 2010[39]	Australia	2008	Early warning/outbreak detection Surveillance during a mass gathering/unique event Signify start/end of seasonal pathogen Assistance during novel threats/emergencies/ natural disasters	Comparison of ED chief complaint to notifiable diseases, FoodNet data and institutional outbreak data	38% of signals were investigated to the subgroup level with an internal investigation for 3% and an external investigation of 0.6% 14% of signals related to a syndrome of public health interest
Jossernan et al. PLoS One 2010[40]	France	Jun–Aug 2006	Surveillance during a mass gathering/unique event	Evaluation of a system for monitoring heat-related illness using ED data	For overall ED visits, sensitivity was highest for the elderly (0.38) Among the elderly, sensitivities for specific syndromes were malaise (0.85), dehydration (0.77) and hyponatremia (0.77)
Kirkwood et al. J Public Health Manag Pract 2007[42]	United States	2003–2005	System evaluation	Economic evaluation of a syndromic surveillance system based on ED chief complaint data	Total cost $422,899 US (development and implementation) and $196,302 US (yearly operating)

Reference	Country	Study Period	Use	Intervention	Outcome
Kwan-Gett et al. Disaster Med Public Health Prep 2009[92]	United States	2009	Signify start/end of seasonal pathogen	Comparison of ED chief complaint (ILI) and influenza data from sentinel providers and laboratory results during H1N1 outbreak	Identification 2 weeks prior to sentinel and 3 weeks prior to laboratory testing
Lemay et al. Biosecur Bioterror 2008[93]	Canada	1998–2003	Early warning/outbreak detection Signify start/end of season pathogen	Comparison of ED chief complaint to laboratory confirmation of influenza	Identification 3–4 weeks prior to laboratory confirmation, primarily in children ≤5 years
Lober et al. J Urban Health 2003[95]	United States	1999–2002	Assistance during novel threats/emergencies/ natural disasters	Description of a surveillance system using patient visits to EDs and primary care clinics to identify bioterrorist attacks	No analysis
Lu et al. Int J Med Inform 2009[96]	Taiwan	2004–2005	System evaluation	Description of a system for extracting phrases from Chinese chief complaints and translating into English (MIM) and comparing to 2 other translation programs (Google translation and a bilingual dictionary)	Sensitivity ranged from 77%–97%, depending on syndrome Specificity of MIM (97%–99%) was similar to Google translation and the bilingual dictionary, with the exception of the GI syndrome, which had higher specificity in MIM (98%) than the bilingual dictionary (70%)
Marx et al. Am J Public Health 2006[85]	United States	Aug 16–18, 2003	Assistance during novel threats/emergencies/ natural disasters	Detection of risk factors for diarrheal illness during a power outage	No analysis

Reference	Country	Study Period	Use	Intervention	Outcome
May et al. West J Emerg Med 2010[19]	United States	2005–2006	Signify start/end of seasonal pathogen	ED chief complaint and diagnosis data categorized into 3 syndromes (viral, upper respiratory infection, pneumonia) compared to sentinel physician consultation data for influenza	Only upper respiratory infection complaints flagged at the beginning of the influenza outbreak in winter 2006 With syndromes combined, the diagnosis data flagged earlier than sentinel physicians. Discharge diagnosis flagged at the same time as sentinel physicians 29% of presenting patients had a different discharge diagnosis than chief complaint
McLeod et al. Aust NZ J Public Health 2009[97]	New Zealand	2005	Signify start/end of seasonal pathogen	Comparison of ED chief complaint data to school absenteeism	Alerted 9 days before school notification
Metzger et al. MMWR Morb Mortal Wkly Rep 2004[32]	United States	2003	Situational awareness	Comparison of ED visits for ILI and diarrheal illness to a telephone survey asking about ILI and diarrheal illness to estimate numbers of citywide illness represented by each ED visit	Every ED visit for ILI represented 60 community illnesses and every ED visit for diarrheal disease represented 251 community illnesses
Meurer et al. J Am Geriatr Soc 2009[98]	United States	2007	Early warning/outbreak detection	Description of a search algorithm to scan the ED census for patients with 2+ systemic inflammatory response syndrome criteria and comparison to discharge diagnosis	Identification via the algorithm had a 1.63 relative risk of infection (95% CI 1.09–2.44). Sensitivity: 14% Specificity: 98%
Mikosz et al. MMWR Morb Mortal Wkly Rep 2004[34]	United States	Jan–Jun 2002	System evaluation	Comparison of 2 free-text ED chief complaint coding systems for agreement	Kappa = 0.614 Agreement was best for the rash syndrome (0.711), followed by the respiratory syndrome (0.594), constitutional (0.419) and GI (0.270)

Reference	Country	Study Period	Use	Intervention	Outcome
Neill. Int J Health Geogr 2009[99]	United States	2008-9	Early warning/outbreak detection	Comparison of 12 spatial scan methods for the detection of synthetic outbreaks	No analysis
New South Wales. Euro Surveill 2006[30]	Australia	2009	Assistance during novel threats/emergencies/ natural disasters	Description of the H1N1 outbreak in New South Wales	No analysis
O'Connell et al. Emerg Infect Dis 2010[29]	United States	Mar–Dec 2008	Early warning/outbreak detection	Description of the implementation of new queries of Electronic Surveillance System for the Early Notification of Community Based Epidemics (ESSENCE), which categorized ED chief data into 11 syndromes and comparison to historical query system	Cluster of meningococcemia cases detected that would have been missed by existing queries
Ozonoff et al. MMWR Morb Mortal Wkly Rep 2004[100]	United States	1996–2000	System evaluation	Description of statistical tests using temporal and spatial data for the identification of clusters	Increased detection power
Schindeler et al. BMC Infect Dis 2009[26]	Australia	2001–2006	Signify start/end of seasonal pathogen Early warning/outbreak detection	Comparison of ED visits to laboratory-confirmed RSV and influenza cases by week	All acute respiratory syndrome and all respiratory syndrome definitions of ED data peaked weeks before laboratory confirmation for influenza

Reference	Country	Study Period	Use	Intervention	Outcome
Shapiro. MMWR Morb Mortal Wkly Rep 2004[35]	United States	—	System evaluation	Description of automated approach to improving ED chief complaint free-text entry (correction of spelling and typographic errors, use of ICD-9 codes for mining)	Text normalization simultaneously reduced the number of false positives and false negatives in syndrome classification, compared with commonly used methods based on word stems. In approximately 25% of instances, using text normalization to detect lower respiratory syndrome would have improved the sensitivity of current word stem approaches by approximately 10%–20%
Shih et al. Infect Control Hosp Epidemiol 2007[23]	Taiwan	2003	Assistance during novel threats/emergencies/ natural disasters	Survey of health care workers regarding the use of syndromic surveillance system during SARS	Atypical clinical presentation was identified as the most common surveillance problem
Silka et al. Am J Emerg Med 2003[101]	United States	1997–2000	Signify start/end of seasonal pathogen Situational awareness	Comparison of patients presenting with ED chief complaint categorized as *fever/infection* versus *respiratory*	No analysis

Reference	Country	Study Period	Use	Intervention	Outcome
South et al. AMIA Annu Symp Proc 2008[102]	United States	Oct 2003–Mar 2004	System evaluation	Determination of the best sources of ED data (chief complaint text, ED visit notes and triage notes) for ILI surveillance and comparison to the complete electronic medical record data	Sensitivity was highest (89%) when the text classifier was based on the full note corpus (all notes combined) and lowest (4%) when nurse triage notes were used PPVs were highest when the text classifier was applied to the chief complaint, ED and combined surveillance document sources. PPV based on all combined surveillance document sources (27%) was higher than for the full note corpus and had a sensitivity of 75% and high specificity 96%
Townes et al. J Public Health Manag Pract 2004[41]	United States	2001	Situational awareness	Comparison of ED data to chart review and hospital discharge diagnosis for surveillance of respiratory syndrome for bioterrorism	Sensitivity 68% (versus chart review) and 62% (versus hospital discharge diagnosis) Specificity 98% with chart review or hospital discharge diagnosis as the gold standard PPV 91% (versus chart review) and 59% (versus hospital discharge diagnosis)
Travers et al. Acad Emerg Med 2006[36]	United States	2000–2001	System evaluation	Description of the standardization of ED chief complaint data	After cleaning, 82% of chief complaints matched a Unified Medical Language System concept

Reference	Country	Study Period	Use	Intervention	Outcome
Travers et al. AMIA Annu Symp Proc 2006[44]	United States	Dec 1, 2005	System evaluation	Comparison of the timeliness of ED diagnosis versus chief complaint for syndromic surveillance	After 12 hours, 60% of the visits and chief complaints had been transmitted, compared to almost no diagnoses. At 24 hours, 89% of the visits/chief complaints had been sent, and 12% of visits had at least one diagnosis code. By the end of 2 weeks, all chief complaints were available, compared to 64% of visits who had a diagnosis. After 12 weeks, 86% of visits had one or more diagnoses
Travers et al. AMIA Annu Symp Proc 2007[37]	United States	2004–2005	System evaluation	Description of the text processing of ED chief complaint data using a query processor and validation against clinical experts	Sensitivity: 23% Specificity: 97%
Turner et al. Commun Dis Intell 2006[25]	Australia	2004	Supplement influenza surveillance	Reporting on ILI consultation rates and performing point of care influenza testing	53 patients met case definition for ILI; 76% tested and no positives for influenza
Van Dijk et al. Emerg Infect Dis 2009[27]	Canada	2004–2006	Early warning/outbreak detection	Comparison of ED chief complaint data to Telehealth calls and NACRS for monitoring of respiratory disease trends	Correlation coefficient 0.91 (Telehealth) and 0.98 (NACRS)
Wallace et al. Am J Emerg Med 2009[103]	United States	Jan 19, 2005	Early warning/outbreak detection	Description of a field simulation to detect a cluster of febrile respiratory illness	No signal was detected
Wang et al. Emerg Med J 2006[104]	Taiwan	Mar–Jun 2003	Assistance during novel threats/emergencies/ natural disasters	Description of an ED scoring tool to properly screen and isolate patients during SARS	With a 1-point cut-off Sensitivity: 81.8% Specificity: 73.6% With a 3-point cut-off Sensitivity: 95.5% Specificity: 87.2%

Reference	Country	Study Period	Use	Intervention	Outcome
Yli-Hietanen et al. Int J Med Inform 2009[38]	United States	—	System evaluation	Description of a model to normalize free text from hospital ED chief complaint data	86% of the chief complaints were completely normalized, and 99% were correctly normalized without adding in approximate matching. When this matching was introduced, the percentage normalized increased to 89%, while the proportion correctly normalized decreased slightly, to 98%
Zheng et al. BMC Public Health 2007[17]	Australia	2001–2005	Early warning/outbreak detection	Comparison of diagnosis of influenza in ED to laboratory influenza test results to detect changes in influenza activity	Alert 3 days earlier (5 year average) Annual range of 3–18 days

Reference	Country	Study Period	Use	Intervention	Outcome
Emergency Medical Services, 911 Calls and Emergency Preparedness					
Baer. Disaster Med Public Health Prep 2011[105]	United States	Dec 15–24, 2006	Surveillance during a mass gathering/unique event	Comparison of emergency medical services assessment for carbon monoxide poisoning to ED chief complaint during a power outage	79% were exactly identified in the syndromic data, 8% were likely matches, 6% were possible matches and 8% could not be matched
Coory et al. J Public Health 2009[47]	Australia	1997–2005	Early warning/outbreak detection Situational awareness	Comparison of ambulance dispatch data to community sentinel ILI rates	During influenza season, ambulance dispatch data demonstrated similar trends to sentinel ILI data sources
Greenko et al. J Urban Health 2003[49]	United States	Jan 19, 1999	Situational awareness	Comparison of 911 dispatch codes to ED visit data for ILI	Sensitivity: 58% Specificity: 64%
Murray et al. Public Health Rep 2009[106]	United States	Sept 3–19, 2005	Early warning/outbreak detection Surveillance during a mass gathering/unique event	Description of a system for daily monitoring for GI and respiratory symptoms	No analysis
New South Wales. Euro Surveill 2006[30]	Australia	2009	Assistance during novel threats/emergencies/ natural disasters	—	No analysis
Williams et al. Epidemiol Infect 2009[48]	Germany	2006	Surveillance during a mass gathering/unique event Situational awareness	Comparison of enhanced system during a mass event to the routine surveillance system	Median interval from date of onset to report being received at the national surveillance centre fell from 17 in 2005 to 12 in 2006. Detection of World Cup–related events was 44% (8/18) in the routine surveillance and 77% (14/18) in supplemental reports
Zielinski et al. Przegl Epidemiol 2009[107]	—	—	Surveillance during a mass gathering/unique event	—	No analysis

Reference	Country	Study Period	Use	Intervention	Outcome
Non–Emergency Department Health Records					
Bellika et al. Int J Med Inform 2007[59]	Norway	—	Situational awareness	Simulation testing of the use of electronic GP visit data for syndromic surveillance	No analysis
Brabazon et al. Euro Surveill 2010[57]	Ireland	2003–2009	Signify start/end of seasonal pathogen	Comparison of calls to one centre covering two GP services to national ILI rates	Peaks in influenza-related calls to out-of-hours service detected at least 1 week earlier in 5 of 6 influenza seasons
Burkom et al. Stat Med 2007[108]	United States	—	System evaluation	Comparison of 3 forecast methods using data from military clinic visit diagnoses and prescriptions and civilian office visits for respiratory and GI illness to standard alerting algorithms	Questionable practical use at time of study without reliable data classification methods.
Cadieux et al. BMC Public Health 2011[109]	Canada	2005–2007	Situational awareness	Assessment of the accuracy of syndrome definitions based on diagnostic codes from a representative sample of physician claims in community settings	Low sensitivity: 0.11 for fever to 0.44 for respiratory PPV: 0.59 for fever to 0.85 for respiratory
CDC. MMWR Morb Mortal Wkly Rep 2011[110]	United States	2009	Early warning/outbreak detection	Comparison of the Electronic Surveillance System for the Early Notification of Community Based Epidemics (ESSENCE) to medical charts and laboratory results for ILI	Sensitivity: 71.4% for medical charts and 78.6% for laboratory-confirmed infections PPV: 31.8% for medical charts and 49.5% for laboratory-confirmed infections
Chan et al. J Biomed Inform 2011[55]	Canada	1998–2003	Early warning/outbreak detection	Comparison of outpatient physician billing data for ILI to viral isolate data and hospital admission records	Alert 2 weeks earlier Increases in ILI visits by children provided the earliest signal of an epidemic

Reference	Country	Study Period	Use	Intervention	Outcome
Chen et al. Ann Acad Med Singapore 2006[111]	Singapore	2002	Early warning/outbreak detection	Comparison of primary care consults for ILI in an army medical centre to real SARS laboratory data	Sensitivity exceeded 90% to detect outbreak sizes of 20 or more cases (provided 80% of cases report their illness to primary care). A sensitivity of 100% was only achieved for outbreak sizes of 30 or more
Deepa. Natl Med J India 2008[112]	India	May–Jun 2005	System evaluation	Description of a weekly reporting system for health events and syndromes involving women's self-help groups and local community groups Comparison of reporting completeness to existing disease surveillance systems	Completeness of reporting was better achieved by women's self-help groups (91.6%) than members of *Panchayati raj* institutions (66.6%) Data capture was more complete compared to the existing disease surveillance system
Flamand et al. Euro Surveill 2008[50]	France	2005–2006	Early warning/outbreak detection Signify start/end of seasonal pathogen	Comparison of GP house calls to national sentinel surveillance network	Correlation coefficient: 0.92
Freedman et al. N Engl J Med 2010[113]	Worldwide	1996–2004	Geo-sentinel surveillance	Description of the occurrence of specific diagnoses among ill returning travellers visiting travel/tropical medicine clinics	No analysis
Hall et al. Epidemiol Infect 2010[114]	Australia, Canada, United States	2000–2002	System evaluation	Description of a telephone survey that used a case definition of gastroenteritis that excluded cases with concurrent respiratory symptoms	Excluding GI cases with respiratory symptoms decreased the incidence of GI disease by 10–50%

Reference	Country	Study Period	Use	Intervention	Outcome
Hripcsak et al. J Am Med Inform Assoc 2009[60]	United States	2003–2004	Early warning/outbreak detection	Comparison of electronic health record data (structured and narrative) from community health centres to ED chief complaint and influenza isolates	Influenza Isolates correlated with the structured data (0.89) and narrative (0.84) ED data correlated with the structured data (0.93) and narrative (0.88) Gastroenteritis structured data from community health centre correlated very well with the ED chief complaint (0.81); the narrative data were poorly correlated (0.47)
Jefferson et al. J Public Health 2008[115]	French Guiana	2005–2006	System evaluation	Comparison of a real-time armed forces syndromic surveillance system to traditional weekly surveillance	Traditional surveillance reported more cases of fever than syndromic surveillance by 12.6% (2005) and 8.4% (2006) Significant correlation (p=0.0431 in 2005 and p=0.0001 in 2006)
Jung et al. J Public Health 2009[116]	United States	1999	System evaluation	Cost benefit analysis of using all encounters in clinic data versus excluding repeat encounters with the same syndrome	70, 68, 21 and 15 signals detected when using all encounters versus 15–20, 3, 4–5 and 0 signals when using only new episodes for lower respiratory, lower GI, upper GI and neurologic syndromes
Kawana et al. Jpn J Infect Dis 2006[117]	Japan	2003–2006	Early warning/outbreak detection	Describes the investigation of all reports of acute respiratory symptoms in hospital patients and staff and the ability to detect outbreaks	Outbreak of influenza coincided with national peak influenza prevalence

Reference	Country	Study Period	Use	Intervention	Outcome
Lober et al. J Urban Health 2003[95]	United States	—	Assistance during novel threats/emergencies/ natural disasters	Description of a surveillance system to detect bioterrorism attacks and disease outbreaks through automatic data collection of discharge diagnosis and data mining of records of EDs, urgent care departments and primary care clinics	No analysis
Meynard. Med Inform Decis Mak 2008[54]	Guiana	2006	Early warning/outbreak detection	Comparison of military nurse and GP syndromic surveillance to civilian clinical and laboratory surveillance	Detected dengue outbreak 3–4 weeks earlier
Najmi et al. BMC Med Inform Decis Mak 2009[118]	United States	—	—	—	No analysis
New South Wales. Euro Surveill 2006[30]	Australia	2009	Assistance during novel threats/emergencies/ natural disasters	—	No analysis
Nordin et al. J Infect Dis 2004[119]	United States	1994–1998	Situational awareness	Description of surveillance system based on database searches at a managed care organization for cases of measles-like illness and comparison to traditional public health surveillance	PPV (ICD-9): 0.3% PPV (combined ICD-9 and text string search): 13.5% Measles incidence (medical records): 0.5 cases/100,000 Measles incidence (public health surveillance data): 0.61/100,000

Reference	Country	Study Period	Use	Intervention	Outcome
Pattie et al. Qual Manag Health Care 2009[120]	United States	2007–2008	Situational awareness	Comparison of electronic body temperature reporting to laboratory-confirmed respiratory viruses and ICD-9 coded for ILI	Sensitivity: 40% for influenza and 15% for other ILI pathogens Specificity: 76% for influenza and 89% for other ILI pathogens
Sloane et al. Ann Fam Med 2006[58]	United States	2003–2004	Signify start/end of seasonal pathogen	Comparison of physician billing data to state surveillance and ED data for influenza	Earlier finding of influenza in physician practice compared to ED
Smith S et al. Euro Surveill 2010[51]	United Kingdom	Jun–Jul 2008	Early warning/outbreak detection Situational awareness	Comparison clinical consultation electronic data (QSurveillance) to confirmed cases of cryptosporidiosis during an outbreak	Rise in consultation rates for gastroenteritis 1 week before outbreak 422 excess diarrhea cases detected, as opposed to 33 clinical outbreak cases
Smith et al. Euro Surveill 2011[56]	United Kingdom	—	Early warning/outbreak detection Situational awareness	Comparison of NHS Direct (telephone health line) to Qsurveillance (national electronic medical records system)	Detected an increase in H1N1 community transmission 1 week earlier than GP consultation data
Takahashi et al. Int J Health Geogr 2008[61]	United States	Aug 2005	Early warning/outbreak detection	Comparison of flexible scan statistic to cylindrical scan statistic using existing medical records surveillance data source	Use the cylindrical scan statistic to detect new outbreaks (because it was more timely) but then use the flexible scan statistic to monitor the spread of the outbreak (more accurately described geographical extent of outbreak)
Van den Wijngaard et al. PLoS One 2010[121]	Netherlands	1999–2006	Early warning/outbreak detection	Comparison of LRI as discharge or secondary diagnosis to Legionnaire's diagnoses, ILI activity and known spikes in influenza and RSV activity to detect outbreaks	Known Legionnaire's disease outbreaks detected as clusters, and 1 detected 4 days earlier

Reference	Country	Study Period	Use	Intervention	Outcome
Van den Wijngaard et al. Epidemiol Infect 2011[52]	Netherlands	2007–2009	Early warning/outbreak detection	Comparison of hospitalization data for syndromes indicative of Q fever to voluntarily reported Q fever–related abortion data and outbreaks on human Q fever illness	Timing of cluster detection using hospitalization data corresponded to timing of known outbreak; was 6 weeks earlier than positive isolation of etiologic agent; and was 3 months to 2 years before known outbreak was detected
Van den Wijngaard et al. Euro Surveill 2011[7]	Netherlands	2002–2003	Early warning/outbreak detection Monitoring disease burden	Syndromic surveillance data compared to laboratory confirmed respiratory pathogens	Winter peaks concurrent with peaks in influenza virus, RSV and other respiratory pathogens; 68% of variations explained by respiratory pathogens Alert 2 weeks ahead of RSV, 4–5 weeks ahead of influenza
Yih et al. MMWR Morb Mortal Wkly Rep 2005[62]	United States	2001–2002	Early warning/outbreak detection	Comparison ambulatory care data to department of health data for detecting of GI outbreaks	No previously known outbreaks of GI illness were detected
Yih et al. Public Health Rep 2010[63]	United States	2007–2008	Early warning/outbreak detection	Comparison of electronic medical records as a syndromic surveillance source to traditional public health surveillance systems	Outbreaks detected by traditional surveillance were not detected by electronic medical records Electronic medical records did detect 2 clusters of varicella

Reference	Country	Study Period	Use	Intervention	Outcome
Online Resources					
Carlson et al. Commun Dis Intell 2009[122]	Australia	2007	Early warning/outbreak detection Monitoring disease burden	Comparison of Flutracking (Internet-based community ILI syndromic surveillance system) to laboratory-confirmed influenza	Correlation coefficient: 0.44 to 0.65 for unvaccinated respondents
Carneiro et al. Commun Infect Dis 2009[64]	United States	—	Early warning/outbreak detection	Comparison of Google Flu Trends to unspecified CDC surveillance data	Detected regional outbreaks of influenza 7–10 days earlier
Dalton et al. Commun Dis Intell 2006[65]	Australia	2006–2008	Situational awareness Early warning/outbreak detection	Comparison of Internet self-reported illness (Flutracking) to other traditional syndromic and laboratory-based surveillance systems for influenza	Peak on influenza activity in 2008 coincided
Eysenbach. AMIA Annu Symp Proc 2006[67]	Canada	2004–2005	Early warning/outbreak detection	Comparison of keyword triggered link in Google Adsense to PHAC Fluwatch numbers of ILI	Predicted flu events by approximately 1 week Correlation coefficient: 0.91 If a threshold of 150 clicks per week were used as a trigger, all 11 weeks with ≥524 flu cases could be predicted with 100% sensitivity and specificity
Goel et al. Proc Natl Acad Sci USA 2010[123]	United States	—	Situational awareness	—	No analysis
Hulth et al. PloS One 2009[68]	Sweden	2005–2007	Signify start/end of seasonal pathogen	Comparison of queries to a medical web site on ILI versus laboratory-diagnosed influenza and ILI sentinel system	R^2: 0.89 (sentinel data) R^2: 0.90 (laboratory data)

Reference	Country	Study Period	Use	Intervention	Outcome
Jaeger et al. J Am Coll Health 2011[10]	Canada	2009	Early warning/outbreak detection	Brock University GotFlu channel (student online self-reporting) versus local primary and secondary school daily absenteeism	Outbreak detected >1 week earlier
Pattie et al. Qual Manag Health Care 2009[120]	United States	2007–2008	Situational awareness	Comparison of electronic body temperature reporting to laboratory-confirmed respiratory viruses and ICD-9 coded for ILI	Sensitivity: 40% for influenza and 15% for other ILI pathogens Specificity: 76% for influenza and 89% for other ILI pathogens
Sugiura et al. Epidemiol Infect 2010[66]	Japan	July 2008	Early warning/outbreak detection Surveillance during a mass gathering/unique event	Comparison of a Web-based daily health questionnaire to existing outpatient syndromic surveillance sources	Sensitivity/specificity respectively for the verification experiment in Izumo (non-G8 data) were as follows: fever (0.43, 0.88), coughing (0.16, 0.80), diarrhea (0.68, 0.77), vomiting (0.55, 0.80), rashes (0.00, 0.89), convulsions (0.00, 0.92) During G8, when examining all symptoms, 13 alerts were reported by the Web-based system. A comparison with the sentinel surveillance system revealed that 12 were false-positive alerts
Valdivia et al. Euro Surveill 2010[69]	Europe	2009–2010	Situational awareness	Comparison of Google Flu Trends to sentinel physician network data	Correlation: 0.72 to 0.94
Wethington et al. Environ Health 2006[124]	United States	2002–2004	Early warning/outbreak detection	Comparison of RUSick2 (an Internet forum for individuals with sudden onset of diarrhea or vomiting to compare information on what they had eaten prior to becoming ill) to telephone reports made to public health department	No analysis

Reference	Country	Study Period	Use	Intervention	Outcome
Pharmacy Sales					
Burkom et al. Stat Med. 2007[108]	United States	2006-7	—	—	No analysis
Burkom et al. MMWR Morb Mortal Wkly Rep 2004[125]	United States	—	Early warning/outbreak detection	Comparison of detection algorithms to known respiratory and GI outbreaks	Event detected 1 day earlier from outbreak start date
Edge et al. Can J Infect Dis Med Microbiol 2006[74]	Canada	2001–2004	Signify start/end of seasonal pathogen	Comparison of OTC sales of medication related to GI illness to laboratory-confirmed cases of GI illness in the National Enteric Surveillance Program	Temporal patterns of OTC sales were most closely synchronized with norovirus infections, with a R^2 of 0.44 in the same week (lag 0).
Kirian et al. BMC Inform Decis Mak 2010[75]	United States	—	Early warning/outbreak detection	OTC diarrheal remedy sales records compared to detected GI outbreaks and individual cases	Sensitivity: 4%–14% Specificity: 97%–100%
Magruder. Johns Hopkins Appl Tech Digest 2003[71]	United States	2001–2003	Early warning/outbreak detection	Comparison of OTC pharmaceutical sales to insurance claims	90% correlation between flu-remedy sales and physician diagnosis of acute respiratory condition Sales occurred 2.8 days earlier than physician-patient encounter
Marx et al. Am J Public Health 2006[85]	United States	Aug 16–18, 2003	Assistance during novel threats/emergencies/ natural disasters	Detection of risk factors for diarrheal illness during a power outage	No analysis
Najmi et al. BMC Med Inform Decis Mak 2004[73]	United States	—	Situational awareness	Comparison of OTC pharmaceutical sales and ED data on acute respiratory conditions	Sales of OTC flu remedies well correlated with physician diagnosis of acute respiratory conditions
Najmi et al. BMC Med Inform Decis Mak 2005[126]	United States	2001–2003	Early warning/outbreak detection	Comparison of OTC pharmaceutical sales and outpatient physician diagnoses	No analysis

Reference	Country	Study Period	Use	Intervention	Outcome
Najmi et al. BMC Med Inform Decis Mak 2009[118]	United States	—	—	—	No analysis
Neill. Int J Health Geogr 2009[99]	—	—	Early warning/outbreak detection	—	No analysis
Sokolow et al. MMWR Morb Mortal Wkly Rep 2005[127]	United States	Jun–Nov 2004	Early warning/outbreak detection	Use of CDC's Biointelligence Center in monitoring syndromic surveillance data and detecting anomalies	No analysis
Van den Wijngaard et al. Emerg Infectious Dis 2008[8]	Netherlands	2002–2003	Early warning/outbreak detection Signify start/end of seasonal pathogen	Syndromic surveillance data compared to laboratory-confirmed respiratory pathogens	Strong correlation between respiratory syndromic data sources and seasonal increases in several respiratory pathogen peaks
Van den Wijngaard et al. Euro Surveill 2011[7]	Netherlands	2002–2003	Early warning/outbreak detection Monitoring disease burden	Syndromic surveillance data compared to laboratory-confirmed respiratory pathogens	Winter peaks concurrent with peaks in influenza virus, RSV and other respiratory pathogens; 68% of variations explained by respiratory pathogens Alert 2 weeks ahead of RSV, 4–5 weeks ahead of influenza
Vergu et al. Emerg Infect Dis 2006[72]	France	2000–2004	Signify start/end of seasonal pathogen	Comparing medical sales to ILI incidence reported by sentinel network of GPs	Correlation between ILI incidence and the forecast was 0.85-0.96
Way et al. Commun Dis Intell 2010[128]	Australia	July 15–Aug 28 2009	Assistance during novel threats/emergencies/ natural disasters	Assess spread and burden of ILIs through antiviral distribution data	No analysis

Reference	Country	Study Period	Use	Intervention	Outcome
Sentinel Community Health Care Providers					
Burkom et al. MMWR Morb Mortal Wkly Rep 2004[125]	United States	—	Early warning/outbreak detection	Comparison of detection algorithms to known respiratory and GI outbreaks	Event detected 1 day earlier from outbreak start date
Clothier et al. Commun Dis Intell 2005[77]	Australia	2002–2004	System evaluation	Evaluation of Australian Sentinel Practice Research Network for ILI surveillance and comparison to ILI data from other influenza surveillance systems	No analysis
Coory et al. Euro Surveill 2009[78]	Australia	1999–2008	Situational awareness	Comparison of an out-of-hours service for GP consultation in the home to ILI data from sentinel physicians	Close agreement between the systems during higher-than-expected seasonal activity (ROC AUC 0.91, 95% CI 0.83–0.98)
Flahault et al. Stat Methods Med Res 2006[129]	France	—	Situational awareness	Description of weekly data reported on 12 conditions, including acute diarrhea and ILI	No analysis
Gault et al. J Public Health 2009[130]	France	—	Signifying the start/end of a seasonal pathogen	Comparison of the ability to identify ILI outbreaks by SOS Medecins (a network of GPs responding to private house calls 24/7) versus sentinel network (1200 physicians)	Epidemic periods identified 2.5 weeks earlier Sensitivity and specificity of 93% at a threshold of 230 weekly visits Correlation coefficient: 0.87
New South Wales. Euro Surveill 2006[30]	Australia	2009	Assistance during novel threats/emergencies/ natural disasters	—	No analysis

Reference	Country	Study Period	Use	Intervention	Outcome
Singh et al. BMC Public Health 2010[76]	Scotland	2001–2009	Early warning/outbreak detection	Comparison of weekly case ratio of reported ILI cases to existing moving-average cumulative sums and ILI threshold methods for outbreak detection	Detection at 3–5 weeks versus 4–6 weeks
Turner et al. Commun Dis Intell. 2006[25]	Australia	2004	Supplement influenza surveillance	Reporting on ILI consultation rates and performing point-of-care influenza testing	53 patients met case definition for ILI; 76% tested and no positives for influenza
Valdivia et al. Euro Surveill 2010[69]	Europe	2009–2010	Situational awareness	Comparison of Google Flu Trends to sentinel physician network data	Correlation 0.72–0.94
Van den Wijngaard et al. Emerg Infect Dis 2008[8]	Netherlands	2002–2003	Early warning/outbreak detection Signify start/end of seasonal pathogen	Syndromic surveillance data compared to laboratory-confirmed respiratory pathogens	Strong correlation between respiratory syndromic data sources and seasonal increases in several respiratory pathogen peaks
Yih et al. MMWR Morb Mortal Wkly Rep 2005[62]	United States	2001–2002	Early warning/outbreak detection	Comparison of ambulatory care data to department of health data for detecting GI outbreaks	No previously known outbreaks of GI illness were detected

Reference	Country	Study Period	Use	Intervention	Outcome
Telephone Help Lines					
Brabazon et al. Euro Surveill 2010[57]	Ireland	2003–2009	Signify start/end of seasonal pathogen	Comparison of calls to one centre covering two GP services to national ILI rates	Peaks in influenza-related calls to out-of-hours service detected at least 1 week earlier in 5 of 6 influenza seasons
Caudle et al. Can J Public Health 2009[80]	Canada	2004–2006	Early warning/outbreak detection	Comparison of calls to Telehealth to NACRS ED discharge data for GI illness	r=0.90
Cooper et al. BMC Med 2008[79]	England	2005–2006	Early warning/outbreak detection Situational awareness	Comparison of calls to the NHS Direct telehealth database to laboratory and clinical data	Alert up to 2 weeks prior to ILI consultation rates Correlation between fever calls and increases to a national influenza B outbreak. No apparent spatial correlation between vomiting calls and norovirus activity
Cooper et al. Epidemiol Infect 2006[131]	England	1997	Early warning/outbreak detection	Comparison of diarrheal calls to NHS Direct health helpline to laboratory-confirmed outbreak of cryptosporidiosis	Outbreak not detected
Cooper et al. Epidemiol Infect 2008[132]	England	2004–2005	Early warning/outbreak detection	Comparison of respiratory virus self-sampling among callers with cold and flu symptoms to NHS Direct to existing syndromic surveillance	Positivity rate of NHS Direct samples (16%) lower than established virological surveillance scheme (26%) Peak positivity coincided
Cooper et al. J Infect 2007[82]	England	2002–2004	Situational awareness	Comparison of calls to NHS Direct to laboratory-confirmed respiratory viruses/bacteria	Respiratory viruses responsible for 50% of seasonal variation in NHS Direct respiratory calls
Cooper et al. J Public Health 2007[133]	England	2002–2007	Early warning/outbreak detection	Comparison of calls to NHS Direct to community sentinel ILI reports and laboratory data	2 weeks' advance warning of seasonal influenza activity during 3 of 4 winters (retrospective) and 6 days during prospective evaluation (2006–2007)

Reference	Country	Study Period	Use	Intervention	Outcome
Coory et al. Euro Surveill 2009[78]	Australia	1999–2008	Situational awareness	Comparison of an out-of-hours service for GP consultation in the home to ILI data from sentinel physicians	Close agreement between the systems during higher-than-expected seasonal activity (ROC AUC 0.91, 95% CI 0.83–0.98)
Derby et al. MMWR Morb Mortal Wkly Rep 2005[134]	United States	Jan 1–Mar 31, 2000	Early warning/outbreak detection	Comparison of calls to poison control for foodborne illness to laboratory-confirmed cases	1 of 77 laboratory-confirmed cases were a potential match for poison control data 50 of 58 calls that were consistent with the syndrome definition were coded as unintentional food poisoning by poison control centre staff (sensitivity: 86%) 248 of 249 calls that were *not* consistent with the syndrome definition were also not coded as unintentional food poisoning (specificity: 99.6%)
Elliot et al. Euro Surveill 2010[135]	United Kingdom	2010	Assistance during novel threats/emergencies/ natural disasters	Description of the use of telephone health advice call data during the Icelandic volcanic ash plume	No analysis
Fan. Can J Public Health 2010[14]	Canada	2009	Early warning/outbreak detection Situational awareness	Comparison of Alberta Real Time Syndromic Surveillance Net, including calls to Health Link Alberta, to traditional paper-based surveillance methods	No analysis
Rolland et al. BMC Health Serv Res 2006[81]	Canada	—	Early warning/outbreak detection Situational awareness	Comparison of Ontario's Telehealth to traditional surveillance systems	No analysis

Reference	Country	Study Period	Use	Intervention	Outcome
Smith et al. Euro Surveill 2006[83]	United Kingdom	—	Early warning/outbreak detection Surveillance during a mass gathering/unique event	Comparison of calls to a telephone hotline (NHS Direct) to clinical and laboratory indicators for influenza	Early indication of national increase in fever calls in school-aged children
Smith et al. Euro Surveill 2010[51]	United Kingdom	Jun–Jul 2008	Early warning/outbreak detection Situational awareness	Comparison clinical consultation electronic data (QSurveillance) to confirmed cases of cryptosporidiosis during an outbreak	Rise in consultation rates for gastroenteritis 1 week before outbreak 422 excess diarrheal cases detected as opposed to 33 clinical outbreak cases
Smith et al. Euro Surveill 2011[56]	United Kingdom	—	Early warning/outbreak detection Situational awareness	Comparison of NHS Direct (telephone health line) to Qsurveillance (national electronic medical records system)	Detected an increase in H1N1 community transmission 1 week earlier than GP consultation data
Yih et al. MMWR Morb Mortal Wkly Rep 2005[62]	United States	2001–2002	Early warning/outbreak detection	Comparison ambulatory care data to department of health data for detecting of GI outbreaks	No previously known outbreaks of GI illness were detected

AUC, area under the curve; CDC, Centers for Disease Control; CI, confidence interval; ED, emergency department; EMS, emergency medical service; GI, gastrointestinal; GP, general practitioner; ICD-9, *International Classification of Diseases,* 9th edition; ILI, influenza-like illness; LRI, lower respiratory tract infection; NACRS, National Ambulatory Care Reporting System; NHS, National Health Service; OTC, over-the-counter; PHAC, Public Health Agency of Canada; PPV, positive predictive value; ROC, receiver operating characteristic; RSV, respiratory syncytial virus; SARS, severe acute respiratory syndrome; SD, standard deviation.

TABLE 2: QUALITATIVE ASSESSMENT (USING THE CDC FRAMEWORK[136]) OF SYNDROMIC SURVEILLANCE DATA CHARACTERISTICS INDENTIFIED IN THE SELECTED LITERATURE

Data Source	Surveillance Characteristic								
	Acceptability	Simplicity	Flexibility	Data Quality	Positive Predictive Value	Sensitivity	Representativeness	Timeliness	Stability
Absenteeism: Employee	U	Y	U	N	U	Y	N	Y	U
Absenteeism: School	Y	S (if auto-mated)	U	N	Y	Y	N	Y	S (not opera-tional on week-ends, holidays)
Emergency Department Chief Complaint	Y	Y	Y	S (need for standard case defini-tions)	S (best if combined with laboratory data)	S (varies by syndrome)	S (possible under-reporting)	Y	S
Emergency Medical Services, 911 Calls and Emergency Preparedness	S	S	S	S	N	N	N	Y	S
Non–Emergency Department Health Records	S (need for systems capital-izing on existing data)	N (lack of EMR standard s)	Y	S	Y (for ILI only)	Y (for ILI; unknown for other syndromes)	U	Y (time to response or action not described)	U
Online Resources	Y	S (low opera-tional costs)	S	Y	Y	Y	S (limited to those with access)	Y	S
Pharmacy Sales	S (electronic collection and transfer of data; implied agreement to share data)	Y	S (possible inclusion of addi-tional data fields)	N	N	S	S (voluntary enrolment)	U	U

Data Source	Surveillance Characteristic								
	Acceptability	Simplicity	Flexibility	Data Quality	Positive Predictive Value	Sensitivity	Representativeness	Timeliness	Stability
Sentinel Community Health Care Providers	Y	Y	U	Y	Y	S (improved if combined with specimen collection)	S (over-representation of children and females <65 years)	S (improved if EMR used)	S (lower reporting during holidays)
Telephone Help Lines	Y	Y	U	Y	Y	Y	S (young children and females over-represented; seniors under-represented)	Y	Y

*As per literature review.
EMR, electronic medical records; ILI, influenza-like illness

Y = Yes (evidence reviewed demonstrates the *presence* of this characteristic for the data source)
S = Somewhat (evidence supporting the characteristic was limited or focused on a segment of the population or specific circumstances)
N = No (evidence reviewed demonstrates the *absence* of this characteristic for the data source)
U = Unknown (lack of published literature)
N/A = Not applicable

TABLE 3: RECOMMENDATIONS FOR SYNDROMIC SURVEILLANCE IN ONTARIO

Syndromic Surveillance Data Source	Number of Articles Included in the Review*	Currently in Use in Ontario (Yes/No)	Recommendation*
Absenteeism: Employee	2	Yes (very limited local)	Not recommended at this time
Absenteeism: School	5	Yes (local)	Implement
Emergency Department Chief Complaint	53	Yes (provincial)	Continue with modification
Emergency Medical Services, 911 Calls and Emergency Preparedness	7	No	Not recommended at this time
Non–Emergency Department Health Records	30	No	Investigate further
Online Resources	11	No	Investigate further
Pharmacy Sales	15	No	Not recommended at this time
Sentinel Community Health Care Providers	11	Yes (provincial)	Continue with modification
Telephone Help Lines	16	Yes (provincial)	Continue with modification

**20 publications described more than one data source, therefore, the number of articles totals to 150, not 125.*

Appendix 1: Quality Assessment Tool for Syndromic Surveillance Publications

INTRODUCTION & BACKGROUND

The purpose of this tool is to assess the methodological quality of scholarly articles/publications reporting on some aspect of syndromic surveillance as identified by a keyword search of appropriate databases.

The tool is applied as the second step in an assessment process to articles, which were determined in an initial screening step to be "*relevant to the control of infectious diseases in Ontario.*" Relevance was based on consideration of three perspectives:

- Scientific
- Contextual
- Generalizable

The abstracts or summaries of all articles identified by initial and expanded search criteria were considered jointly by members of the Provincial Infectious Diseases Advisory Committee on Surveillance (PIDAC-S) at its meetings. A determination by any one member of the PIDAC-S that a publication was relevant from any one of these perspectives was the criteria for subjecting it to fuller methodological assessment using this quality assessment tool.

USE OF THE TOOL

Each of two raters drawn from the PIDAC-S membership will independently assess the quality of each study/publication and complete this tool. When each rater is finished, the individual ratings will be compared. While it is not necessary for reviewers to achieve a consensus on each item, the overall difference between the two rater's Global Total Score *must not be greater than 5 points*.

The final score allocated to the study/publication will be the *sum of the two reviewers' scores*.

In cases where the difference in Global Total Score between the two reviewers is greater than 5 points, a third PIDAC-S member will be asked to assess the study, and the final two scores *that are closest* will be summed to determine the final score.

NOTE: Final selection of a minimum Global Total Score threshold will include consideration of the distribution of scores (i.e. inspect for natural cut points), consensus of what are "reasonable" articles and workload, and whether one or more reviewers gave the paper a Global Rating of "A" (very valuable) despite a low score.

INSTRUCTIONS FOR COMPLETION

Circle the appropriate response in each component section (A–F) and complete the Global Rating. Calculate the total summary score from each component sections and record it in the corresponding box. Calculate the Global Total Score by summing each component score. After each individual rater has completed the form, both reviewers must compare their ratings to determine whether a third review is required.

QUALITY ASSESSMENT TOOL FOR SYNDROMIC SURVEILLANCE

Ref ID: ____________________

Author: ____________________

Year: ____________________

Reviewer: ____________________

Component Ratings

A) Representativeness

Are the surveillance systems, data, setting, or populations in the study likely to represent those found in Ontario? (Circle the appropriate score.)

The system/data/setting/population studied is very similar to that of Ontario	score 5
The system/data/setting/population studied is somewhat similar to that of Ontario	score 3
The system/data/setting/population studied is different from that of Ontario, but may represent future trends	score 2
The system/data/setting/population studied is very different from that of Ontario	score 0
REPRESENTATIVENESS total score = _______	

B) Study design

Indicate the study design

Review article/meta-analysis	score 10
Randomized, controlled trial	score 10
Prospective validation study	score 9
Mixed (prospective/retrospective) validation study	score 9
Retrospective validation study	score 8
Prospective descriptive study	score 8
Retrospective descriptive study	score 7
Case control study	score 6
Relevant survey	score 6
Ecological/cross-sectional study	score 5
Simulation/mathematical modelling	score 4
Expert group opinion	score 3
Demonstration project/case study	score 1
Single expert opinion	score 0
STUDY DESIGN total score = _______	

C) Publication/peer review ***Librarian to complete this section for all***

Was the study/article subject to peer review? Was it published in a reputable journal?

Published in peer reviewed journal of high impact/reputation	score 5
Published in peer reviewed journal of lesser impact/reputation	score 3
Not subject to peer review	score 1
PUBLICATION/PEER REVIEW total score = _______	

D) Economic assessment

Did the study/article include a quantitative economic assessment? Cost-effectiveness analysis? etc.

Economic or cost-effectiveness analysis incorporated	score 5
Some costing considerations noted	score 3
No economic/cost-effectiveness analysis included	score 0
ECONOMIC ASSESSMENT total score = ________	

E) Data collection methods

Are the data collection tools/methods adequately described? Valid? Reliable?

Methods are comprehensively described and appear valid and reliable	score 5
Description of methods is not comprehensive, but methods appear reliable	score 3
Methods inadequately described/difficult to assess accuracy	score 1
Methods as described are neither valid nor reliable	score 0
DATA COLLECTION METHODS total score = ________	

F) Analyses

Are the unit of analysis, the statistical or mathematical methodology and the approach to assessing any intervention, confounding, etc. appropriate and accurate for the study design and conclusions?

Analyses are comprehensively described and appear appropriate and accurate	score 5
Description of analyses is not comprehensive, but analyses appear appropriate and accurate	score 3
Analyses are inadequately described/difficult to assess appropriateness and accuracy	score 1
Analyses are either inappropriate or inaccurate	score 0
ANALYSES total score = ________	

Global Rating

Very valuable study	grade A
Valuable study	grade B
Not a useful study	grade C

Brief Rationale for Global Rating:

Global Total Score

TOTAL SCORE = ________	GLOBAL RATING GRADE = ________

Agreement Between Reviewers

Is the overall difference between the two rater's Global Total Scores less than or equal to 5 points?
No Yes
If YES, study/publication must be assessed by a third reviewer.

Appendix 2: Data Extraction Tool

PIDAC-S ABSTRACTION

Article abstraction tool for syndromic surveillance literature review.

Article Information

Abstractor Name ______________________
Article Title ______________________
Article Authors (e.g. Savage R, Gournis E, Winter A et al.) ______________________
Year of Publication ______________________
Journal Name ______________________
Volume, Issue, Page Numbers ______________________

Question 1

Which type(s) of syndromic/proxy data does this article cover (or make significant mention)?

Please check all that apply.
School Absenteeism
Employee Absenteeism
Emergency department chief complaint data
EMS assessment data
911 call dispatch codes
Telephone health line
Pharmacy sales
Sentinel community HCPs
Online search trends (e.g. Google Flu Trends). Specify name: __________________________
Online media sources or bulletin boards (e.g. GPHIN, PROMED). Specify name: __________________________
Internet-based self-reported illness tools. Specify name: __________________________
Social media monitoring (e.g. Twitter, Facebook). Specify name: __________________________
Other. Specify name: __________________________

Question 2

Which of these potential uses of syndromic surveillance does the article cover (or make significant mention)?

Please check all that apply.
Early warning/outbreak detection (real prospective event, not simulation)
Early warning/outbreak detection (simulation models)
Surveillance during a mass gathering/unique event
Ability to signify start/end of seasonal pathogen (e.g. flu or norovirus)
Situational awareness
Assistance during novel threats/emergencies/natural disasters (e.g. pandemic, SARS)
Other, please specify: __________________________
NEW Early warning/outbreak detection (real retrospective)

Early warning/outbreak detection (prospective) (q2a)

You selected “early warning (prospective)”; please enter the following information.
What was the gold standard the syndromic data was compared to? ______________________
Was an event detected earlier in the syndromic data? (Y/N) ______________________
If yes, what was the time difference? ______________________
Did earlier detection result in any public health action? Briefly describe. ______________________
Please capture any additional relevant information here. ______________________

Early warning/outbreak detection (simulation) (q2b)
You selected "early warning (simulation)"; please enter the following information.
What was the gold standard the syndromic data was compared to? ______________________
Was an event detected earlier in the syndromic data? (Y/N) ______________________
If yes, what was the time difference? ______________________
Did earlier detection result in any public health action? Briefly describe. ______________________
Please capture any additional relevant information here. ______________________

Mass gathering/unique event (q2c)
You selected "mass gathering/unique event"; please enter the following information.
Briefly describe the system (e.g. new or existing, syndromes monitored). ______________________
Was the system able to detect a known event—prospectively or retrospectively? ______________________
If prospective, was any public health action taken? Briefly describe action. ______________________
Please capture any additional relevant information here. ______________________

Signify start or end of season (q2d)
You selected "signify start or end of season"; please enter the following information.
What was the gold standard the syndromic data was compared to? ______________________
Was the start/end of season detected earlier in the syndromic data? (Y/N) ______________________
If yes, what was the time difference? ______________________
Did earlier detection result in any public health action? Briefly describe action. ______________________
Please capture any additional relevant information here. ______________________

Situational awareness (q2e)
You selected "situational awareness"; please enter the following information.
Do the authors define situational awareness? (Y/N)___________________
If yes, provide definition.___________________
Are specific situations described where the syndromic data provided situational awareness? (Y/N)___________________
If yes, please briefly describe.___________________
If no, please describe generally how the data provided situational awareness (e.g. used in conjunction with traditional systems). ___________________
Please capture any additional relevant information here.___________________

Novel threats/emergencies/natural disasters (q2f)
You selected "novel threats, etc"; please enter the following information.
What was the threat? (name)__________________
Was the data used to monitor the situation including health service impact (in lieu of or in absence of existing infrastructure)? (Y/N)__________________
If yes, please describe__________________
Was the data used to inform decisions? (Y/N)__________________
If yes, please describe (including which decisions).__________________
Was the data used for a different purpose? (Y/N)__________________
If yes, please describe.__________________
Please capture any additional relevant information here.__________________

Other (q2g)
Please enter any relevant information here, focusing on how syndromic surveillance was used.
____
____
____

Early warning/outbreak detection (real retrospective) (q2h)
You selected "early warning (retrospective)"; please enter the following information.
What was the gold standard the syndromic data was compared to? ______________________
Was an event detected earlier in the syndromic data? (Y/N) ______________________
If yes, what was the time difference? ______________________
Please capture any additional relevant information here. ______________________

Question 3

Which of these considerations for adopting syndromic surveillance does this article cover?

Please check all that apply.
Economic implications
Automation (of analysis, data collection)
Sensitivity and/or specificity
Aberration detection algorithms (or other analytic tools)
Level of public health response and when to trigger it
Other, please specify: ___________________________

Economic implications (q3a)
You selected “economic implications”; please enter the following information.
Briefly describe the resources used. _______________________

Automation (q3b)
You selected “automation”; please enter the following information.
What is automated: data collection, analysis or both? _______________________
Briefly describe automation. _______________________
Describe any impact of the automation (improvement in timeliness or efficiency)? _______________________
Please include any additional relevant information here. _______________________

Sensitivity/specificity (q3c)
You selected “sensitivity/specificity”; please enter the following information.
What was the gold standard the syndromic data was compared to?_________________
Briefly describe its sensitivity (ability to detect true events—true positives)._________________
Briefly describe its specificity (are syndromes monitored specific to the disease of interest or could it also represent other diseases—false positives)._________________
Please include any additional relevant information here._________________

Aberration detection algorithms (q3d)
You selected “aberration dection algorithms”; please enter the following information.
How was the syndromic data analysed (describe approach including algorithms used)? _______________________
Was the approach validated? (Y/N) _______________________
If yes, please briefly describe the validation. _______________________
Please include any additional relevant information here. _______________________

Public health response (q3e)
You selected “public health response”; please enter the following information.
Was there a threshold for alerting or a trigger for investigation based on the analysis? (Y/N) _______________________
If yes, please briefly describe. _______________________
Briefly describe the process for investigating alerts if stated. _______________________
Briefly describe the public health response taken (including the time between alert and response) if stated. _________________
Was a protocol in place to guide the response? (Y/N) _______________________
If yes, please briefly describe. _______________________
Please include any additional relevant information here. _______________________

Other (q3f)
You selected “other”; please include any relevant information here.
____
____
____

Question 4

Does the article list any recommendations for the future of syndromic surveillance?

Please enter in the text box provided below.

____
____
____

Question 5

List any other topics or discussion points mentioned in the article that might be of use to the review.

____
____
____

This is the end of the abstraction tool.

Please ensure you double-check your responses before clicking "Submit" (by selecting the "Back" button).

You can also review your responses by selecting "Review Responses" at the bottom left. This will open your responses in a PDF file, which you can review.

You may wish to save the final PDF so you have a back-up copy for your records. Thank you!

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