Original article

Emergency department syndromic surveillance system for early detection of 5 syndromes: a pilot project in a reference teaching hospital in Genoa, Italy

F. ANSALDI[1 2], A. ORSI[1], F. ALTOMONTE[2], G. BERTONE[2], V. PARODI[1], R. CARLONI[3], P. MOSCATELLI[2], E. PASERO[2], P. ORESTE[4], G. ICARDI [1 2]
[1] Department of Health Sciences, University of Genoa; [2] A.O.U. "San Martino", Genoa; [3] Regional Health Agency, Liguria Region, Genoa; [4] Department of Health and Social Services, Liguria Region, Genoa, Italy

Key words

Syndromic surveillance • Early outbreak detection • Public health • Emergency department

Summary

Early detection is fundamental for achieving effective control of infectious disease outbreaks. We described the development of a local chief complaint emergency department (ED)-based syndromic surveillance system to improve public health response in Genoa, Italy. The five syndromes under investigation by the syndromic surveillance system were influenza-like illness (ILI), low-respiratory tract illness (LRTI), not-haemorrhagic gastroenteritis, acute hepatitis, fever-with-rash (maculo-papular or vescicular) syndrome. Syndrome coding, data capture, transmission and processing, statistical analysis to assess indicators of disease activity and alert thresholds, and signal response were operatively described. Preliminary results on ILI syndromic surveillance showed that new system allowed the activation of the alert state with a specificity of 90.3% and a sensitivity of 72.9% in predicting epidemiological relevant events, such as ≥ 10 accesses to ED for ILI in 3 days. The new syndromic surveillance system allowed to alert the public health institutions 2.5 days before than the local surveillance system based on sentinel physicians and paediatricians, permitting the early activation of the necessary measures for the containment and for burden reduction of the epidemic event. It is noteworthy that the syndromic surveillance epidemic cut-off was overcome once before and 4 times after influenza outbreak detected by sentinel-based surveillance system: all episodes were contemporary with Respiratory Syncytial Virus and Parainfluenza Virus circulation, as detected by regional reference laboratory.

Introduction and aims

Early detection of disease outbreaks plays a fundamental role in minimizing the spread of etiologic agents and in reducing the burden of diseases in the community [1-3]. Classic disease surveillance systems are based on data obtained from patients with suspected or confirmed defined diagnosis; however, a specific clinic diagnosis is sometimes hard to define, or reported signs and symptoms can be ascribed to different etiologic agents, so decreasing timeliness and sensitivity of traditional public health methods [4]. One practical consequence of the difficulties to make a definitive diagnosis is delay in starting case investigation and contact tracing and in reporting epidemiological data. For example, United State Measles Surveillance System showed a wide range in interval between rash onset and report to State Health Department, varying between 0 and more than 60 days, according to State [5].

The need to improve conventional surveillance system of infectious diseases became urgent especially after the 2001 terrorist attacks on the United States and the subsequent anthrax outbreak, that made stakeholders aware of the importance of early detection of infectious diseases [6].

But since 1998 Centers for Disease Control and Prevention (CDC) established among the priorities the development of programs for early detection and investigation of outbreaks [7]; CDC's 2000 strategic plan for biologic and chemical preparedness provided an integration between existing surveillance systems and "new mechanisms for detecting, evaluating, and reporting suspicious events" [8]. For this purpose, a new surveillance approach, named syndromic surveillance has been developed. This investigational method is based on the collection and analysis of constellations of symptoms, complaints, or diagnostic codes that are used to group patients into syndrome categories, in order to monitor disease indicators near real-time and to detect disease outbreaks earlier than traditional surveillance methods [1, 6, 9-12].

In this paper we described an emergency department (ED) chief complaint syndromic surveillance system, realized and evaluated by Department of Health Sciences (DiSSal), University of Genoa, in collaboration with Operative Unit "Clinical governance" and Emergency Department (DEA), San Martino University Hospital.

The main objectives of our surveillance system are (i) to rapidly detect outbreaks of 5 syndromes, (ii) to determine their size, spread and time, (iii) to quickly activate the epidemiological investigation, (iii) to allow a better public health response and (iv) to monitor disease trends.

Syndrome coding

Five syndromes have been under investigation by the sindromic surveillance system described here, namely, influenza-like illness (ILI), low-respiratory tract illness (LRTI), not-haemorrhagic gastroenteritis, acute hepatitis, fever-with-rash (maculo-papular or vescicular) syndrome.
The syndromes object of surveillance were chosen for their primary importance and relevant burden in public health; they have been identified as representing the clinical onset of:

- airborne or feco-oral infections, that are frequent responsible of outbreaks, both in the community and in hospitals; in particular, these infections mainly affect pediatric population, with high risk of hospitalization during the first 5 years of life. ILI and pneumonia are also important causes of morbidity and mortality in high-risk groups, especially the elderly, that represent 27% of Genoa population;
- imported infectious diseases for travellers and migrants (acute A hepatitis, viral diarrhea, etc.);
- exanthematic infectious diseases preventable by vaccination and included in National Elimination Plan (measles, congenital rubella, etc.);
- acute B hepatitis, which represent a sentinel event in an epidemiological picture characterized by universal vaccination of < 25 years old and high risk groups immunization;
- infections caused by critical bioterrorism-associated agents.

In Table I, the operative case definitions that was initially set for each syndrome, based on international standardized definitions, were reported [1, 13-15].
Based on these case definitions, each syndrome was identified by a combination of keywords that must appear in specific fields (anamnesis, case history and comments) of the Emergency Department (ED) registration and triage software.
The keywords identification has been done in collaboration with DEA and Operative Unit "Clinical governance" staff and it was followed by an evaluation phase of different combinations, in order to optimize the case capture, in terms of sensitivity and specificity.
The keywords identified during the assessment phase and that will be used during the surveillance phase, are shown in Table II.

Consultation and preparation

The structure primarily involved in the syndromic surveillance project described here is the regional reference hospital "S. Martino", a 1400-bed teaching hospital in Genoa, Italy. This structure was chosen because it represents the hospital with the largest catchment area in Genoa, with an average of accesses to the emergency room of about 100,000 (range 96,000-120,000) per year.
DiSSal, DEA and Operative Unit "Clinical governance" operators have been involved in several meetings that included epidemiological aspects, organizational facets and technical procedures of registration and electronic transmission of syndromic surveillance data.

Data capture, transmission and processing

An informatic system was developed in order to scan the chief complaint field for the word strings assigned to the single syndrome: the system provides for an automatic review of ED acceptance data folders, identifying

Tab. I. Case definition used for the 5 syndromes object of surveillance.

Syndrome	Case definition
ILI (influenza like illness)	Patient with abrupt onset of fever, at least one systemic symptom, including myalgia, headache, chills, etc. and at least one respiratory symptoms, including, cough, sore throat, nasal congestion, etc.
LRTI (low respiratory tract infection)	Patient with pneumonia or brochiolitis or acute bronchitis or presence of at least two of non-specific symptoms such as cough, stridor, shortness of breath, throat pain, sputum, or pulmonary infiltrate on chest radiography, excluding chronic conditions such as chronic bronchitis, asthma without acute exacerbation, chronic sinusitis, allergic conditions
Not-haemorrhagic gastroenteritis	Patient with acute infection of the upper and/or lower gastrointestinal (GI) tract or presence of acute non-specific symptoms of GI distress such as nausea, vomiting, or diarrhea excluding any chronic conditions such as inflammatory bowel syndrome and patient with blood in faecal specimens or vomit
Acute viral hepatitis	Patient with an acute illness with discrete onset of symptoms (e.g. fatigue, abdominal pain, loss of appetite, intermittent nausea, vomiting), and jaundice or elevated serum aminotransferase levels and positive for (i) IgM antibody to HAV (IgM anti-HAV), Hepatitis B surface antigen (HBsAg) or IgM antibody to hepatitis B core antigen (IgM anti-HBc) or antibody to HCV (anti-HCV)
Fever-with-maculo-papular or vescicular rash	Patient with fever and specific or non-specific diagnosis of rash compatible with infectious disease, excluding allergic or inflammatory skin conditions such as contact or seborrheic dermatitis, rosacea and rash due to poison ivy, sunburn, and eczema

Tab. II. Key word combinations identifying surveyed syndrome that must appear in specific fields of the Emergency Department (ED) registration and triage software.

Syndrome	Anamnesis, case history and comments					
	Keywords					Assess exclusion of
ILI (influenza like Ilness)	Fever	AND	Cough OR Sore Throat OR Dyspnoea	AND	Asthenia OR Myalgia OR Headache OR Photophobia OR Cold Flow	
	OR Influenza					
LRTI (low respiratory tract infection)	Cough AND (Wheezing OR Rale OR Rhonchus) OR Sputum AND (Wheezing OR Rale OR Rhonchus) OR Dyspnoea AND (Wheezing OR Rale OR Rhonchus) OR Tachypnoea AND (Wheezing OR Rale OR Rhonchus) OR Pneumonia OR Bronchopneumonia OR Brochiolitis OR Bronchitis					Asthma, Asthmatic, COPD, Hearth Disease, Cardiac, Chronic
Not-hemorragic gastroenteritis	Vomiting OR Diarrhoea OR Gastroenteritis OR Enteritis					Blood, Melaena, Rectorrhage, Haematemesis, Proctor-rhage, Chron, Ulcerative
Acute hepatitis	Icterus OR Subicterus OR					Chronic Cirrhosis Carcinoma
Fever with rash	Fever	AND	Dermatitis OR Exanthema OR Rash OR Macules OR Papules OR Vescicles			Allergy, Allergic Seborrheic Eczema Rosacea Sun, Solar
	OR Measles OR Rubella OR Varicella					

suspected cases and subdividing them into one of the 5 analyzed clinical syndromes. The chief complaint field was preferred rather than the discharge diagnosis, that is often not coded on the ED acceptance data sheet and is not immediately available electronically in our settings. Several studies showed a high correlation between chief complaints and discharge diagnosis, validating the use of these data in respiratory and gastro-intestinal syndrome early detection system [16-18].

The case capture occurs every morning from 7.30 to 8.00 and affects patients who have come to the emergency room within 24 hours. Details of cases with the keywords in the above mentioned fields are recorded on a Microsoft Office Excel sheet that is sent by e-mail message to DiSSaL for the critical review. Data files contain the following information: visit record number, date of visit, sex, age in years, citizenship code, home zip code, triage colour code, free-text chief complaint, visit outcomes, department admission code. After the receipt of the message, an analyst of DiSSal staff performs a critical revision of each reported case for every syndrome, accepting or rejecting the cases according to the operative case definitions. The confirmed cases are then entered in a specific database for each syndrome and contribute to the evaluation of the impact.

Indicators of disease activity and the alert thresholds

In order to define indicators of activity and the alert thresholds value for each analyzed clinical syndrome, a retrospective analysis of the ED access database from 1 January 2007 until 30 May 2008 was performed. For all syndromes, an indicator and a threshold value that can achieve optimum sensitivity and specificity in predicting epidemiological relevant events was established, using ROC curve approach. Epidemiological events were arbitrary established for every syndromes in collaboration with local health department and hospital ED and according to public health goals: ≥ 10 accesses to ED for ILI in 3 days, ≥ 2 fever-with-rash (maculo-papular or vescicular) or acute hepatitis in 5 days were considered

unexpected, while LRTI and not-haemorrhagic gastroenteritis relevant event are under investigation.
The indicator of activity that reach the highest sensitivity and specificity was, for the studied syndromes, the 5-day moving average.
We reported here the assessment and evaluation processes for the threshold value of one surveyed syndrome, namely ILI.
A threshold value for the syndrome was located equal to a value of 5-day moving average of 1.6 cases per day. This value allows the activation of the alert state with a specificity of 90.3% and a sensitivity of 72.9%, considering a number of hospital admissions for ILI > 10 cases in 3 days as epidemic event. In Figure 1, it is reported the ILI daily case 5-day moving average for the period June 2007-August 2008: using a threshold of 1.6 cases per day, during 2007, the epidemic cut-off was overcome on 23 November 2007 and on 23 December 2007: the first wave was combined with circulation of Parainfluenza Virus type 3 detected by the regional reference laboratory, and it was not pointed out by influenza surveillance network (Inter-university Centre for Research on Influenza and other Viral Infections, CIRI-IV), although the case definition used by the two surveillance system were identical. The beginning of outbreak due to circulation of influenza virus was reported by syndromic surveillance system and influenza surveillance network on 24 December morning and 26 December afternoon, respectively. Syndromic surveillance system allowed to alert the public health institutions 2.5 days before than the surveillance system based on sentinel physicians and paediatricians, permitting the activation of the necessary measures for the containment and for burden reduction of the epidemic event.
It is noteworthy that the syndromic surveillance epidemic cut-off was overcome 4 times after exhaustion of influenza outbreak detected by sentinel-based surveillance system (10 March 2008): all episodes were contemporary with Respiratory Syncitial Virus (RSV) and Parainfluenza Virus (PIV) circulation, as detected by regional reference laboratory. No cut-off break-through were observed in July, August, September and October 2007 and between 15 July and 31 August 2008, when no respiratory viruses were detected.

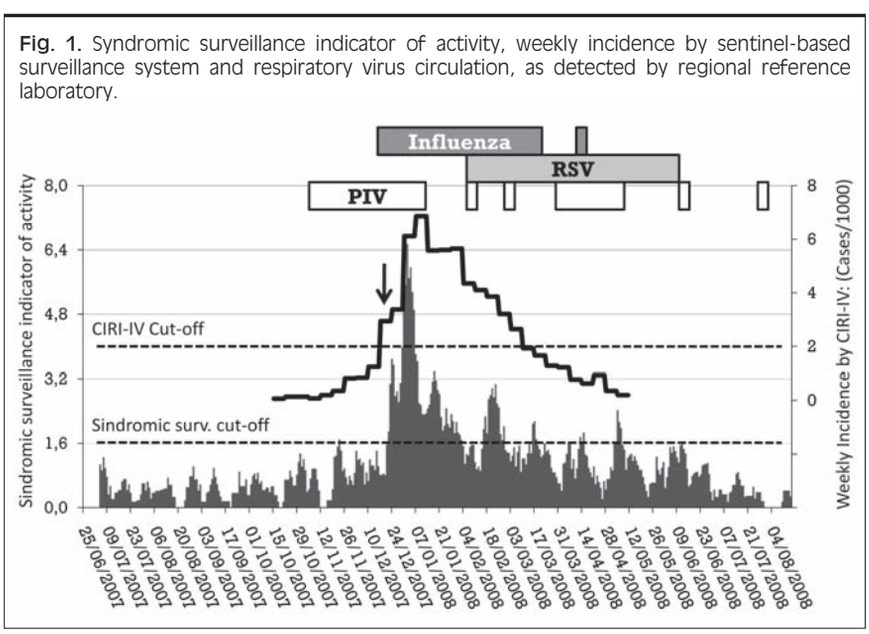

Fig. 1. Syndromic surveillance indicator of activity, weekly incidence by sentinel-based surveillance system and respiratory virus circulation, as detected by regional reference laboratory.

Signal response

When an activity indicator overcome the syndromic surveillance cut-off, different actions were undertaken to evaluate the alarm, including the evaluation of the counts size that contributed to the signal, the magnitude of the increase index, the proportions of patients falling within various subgroups based on age, admission status or triage category to determine whether unusual epidemiological features, including changes in the distribution of the severity of cases, were present, a descriptive epidemiological analysis to compare the demographic characteristics of the period of increase with a control period, such as a recent period or the same period in previous years from different databases.
Finally, if the epidemiologist judged that the initial assessment does not suggest a false alarm and a concern remained after these analyses, public health authority, Regional Health Agency, Regional Department of Health and Social Services and Infectious Disease Units would be informed.

Perspectives and challenges

The primary aim of this project is the organization and validation of a syndromic surveillance system based on the analysis of emergency room acceptance data from the regional reference hospital. This system can usefully complement the information coming from existing surveillance systems already in force in majority of nations, allowing, moreover, a very rapid detection of epidemiological relevant events. Preliminary results on ILI data showed that the new surveillance system is considerable sensible and specific in anticipating both ED access overcrowd and influenza outbreak detected by sentinel-based surveillance system. Data analysis from the 2007/08 season showed that the new system allowed to alert the public health institutions 2.5 days before than the surveillance system based on sentinel physicians and paediatricians, permitting the activation of the necessary measures for the containment and for burden reduction of the epidemic event. An early detection of influenza spread in the community could allow reduction of intra-hospital infection transmission risk and increase of the communication and information capacity among different alert systems,

notably the Information System of Infectious Diseases (SIMI) and the Hospital Information System.
The high sensitivity of the surveillance system was confirmed by 5 epidemic cut-off break-through before and after influenza outbreak detected by sentinel-based surveillance system contemporary with RSV and PIV circulation.
Real time linkages between ED and public health can provide information that enhances outbreak detection and public health response. The system described here showed to be useful in seasonal influenza outbreaks and similar system showed promise in terms of monitoring diverse emergent situations, although additional research and evaluation are required, in particular, to optimize appropriate syndromic definitions, to develop minimally acceptable response protocols and to advance the debate regarding resource commitment for syndromic *vs* traditional surveillance.

References

[1] Buehler JW, Hopkins RS, Overhage JM, Sosin DM, Tong V, CDC Working Group. *Framework for evaluating public health surveillance systems for early detection of outbreaks: recommendations from the CDC Working Group*. MMWR Recomm Rep 2004;53:1-11.

[2] Lober WB, Karras BT, Wagner MM, Overhage JM, Davidson AJ, Fraser H, et al. *Roundtable on bioterrorism detection: information system-based surveillance*. J Am Med Inform Assoc 2002;9:105-15.

[3] Travers D, Barnett C, Ising A, Waller A. *Timeliness of emergency department diagnoses for syndromic surveillance*. AMIA Annu Symp Proc 2006:769-73.

[4] Jajosky RA, Groseclose SL. *Evaluation of reporting timeliness of public health surveillance systems for infectious diseases*. BMC Public Health 2004;4:29.

[5] Harpaz R, Papania MJ, Fujii KE, Redd SB, Wharton ME, Redd SC, et al. *Lessons learned from establishing and evaluating indicators of the quality of measles surveillance in the United States, 1996-1998*. J Infect Dis 2004;189:S196-203.

[6] Henning KJ. *What is syndromic surveillance?* MMWR Morb Mortal Wkly Rep 2004;53:5-11.

[7] CDC. *Preventing emerging infectious diseases: a strategy for the 21st century*. Atlanta, GA: US Department of Health and Human Services, 1998. Available at http://www.cdc.gov/ncidod/emergplan/index.htm

[8] CDC. *Biological and chemical terrorism: strategic plan for preparedness and response: recommendations of the CDC strategic planning workgroup*. MMWR Morb Mortal Wkly Rep 2000;49:1-14.

[9] Buckeridge DL, Burkom H, Moore A, Pavlin J, Cutchis P, Hogan W. *Evaluation of syndromic surveillance systems – design of an epidemic simulation model*. MMWR Morb Mortal Wkly Rep 2004;53:137-43.

[10] Heffernan R, Mostashari F, Das D, Karpati A, Kulldorff M, Weiss D. *Syndromic surveillance in public health practice, New York City*. Emerg Infect Dis 2004;10:858-64.

[11] Bourgeois FT, Olson KL, Brownstein JS, McAdam AJ, Mandl KD. *Validation of syndromic surveillance for respiratory infections*. Ann Emerg Med 2006;47:265.

[12] Chretien JP, Burkom HS, Sedyaningsih ER, Larasati RP, Lescano AG, Mundaca CC, et al. *Syndromic surveillance: adapting innovations to developing settings*. PLoS Med 2008;5:e72.

[13] CDC. *Case definitions for infectious conditions under public health surveillance*. MMWR Morb Mortal Wkly Rep 1997;46:1-13.

[14] CDC. *Guidelines for Viral Hepatitis Surveillance and Case Management*. Atlanta, GA 2005.

[15] CDC. *Syndrome definitions for diseases associated with critical bioterrorism-associated agents*. Atlanta, GA: US Department of Health and Human Services, CDC, 2003. Available at http://www.bt.cdc.gov/surveillance/syndromedef/index.asp

[16] Fleischauer AT, Silk BJ, Schumacher M, Komatsu K, Santana S, Vaz V, et al. *The validity of chief complaint and discharge diagnosis in emergency department-based syndromic surveillance*. Acad Emerg Med 2004;11:1262-7.

[17] Chapman WW, Dowling JN, Wagner MM. *Classification of emergency department chief complaints into 7 syndromes: a retrospective analysis of 527,228 patients*. Ann Emerg Med 2005;46:445-55.

[18] Moore KM, Edgar BL, McGuinness D. *Implementation of an automated, real-time public health surveillance system linking emergency departments and health units: rationale and methodology*. CJEM 2008;10:114-9.

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■ Correspondence: F. Ansaldi, Department of Health Sciences, via Pastore 1, 16132 Genova, Italy - Tel. +39 010 3538503 - Fax +39 010 3538407 - E-mail: filippo.ansaldi@unige.it