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Original Contribution

A test of syndromic surveillance using a severe acute respiratory syndrome model☆

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Abstract

Objectives: We describe a field simulation that was conducted using volunteers to assess the ability of 3 hospitals in a network to manage a large influx of patients with a potentially communicable disease. This drill provided the opportunity to evaluate the ability of the New York City Department of Health and Mental Hygiene's (NYC-DOHMH) emergency department chief complaint syndromic surveillance system to detect a cluster of patients with febrile respiratory illness.

Methods: The evaluation was a prospective simulation. The clinical picture was modeled on severe acute respiratory syndrome symptoms. Forty-four volunteers participated in the drill as mock patients.

Results: Records from 42 patients (95%) were successfully transmitted to the NYC-DOHMH. The electronic chief complaint for 24 (57%) of these patients indicated febrile or respiratory illness. The drill did not generate a statistical signal in the NYC-DOHMH SaTScan analysis. The 42 drill patients were classified in 8 hierarchical categories based on chief complaints: sepsis (2), cold (3), diarrhea (2), respiratory (20), fever/flu (4), vomit (3), and other (8). The number of respiratory visits, while elevated on the day of the drill, did not appear particularly unusual when compared with the 14-day baseline period used for spatial analyses.

Conclusions: This drill with a cluster of patients with febrile respiratory illness failed to trigger a signal from the NYC-DOHMH emergency department chief complaint syndromic surveillance system. This highlighted several limitations and challenges to syndromic surveillance monitoring.

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1. Background

One goal of public health surveillance is the early detection of illness to facilitate targeted interventions aimed at reducing morbidity and mortality [1,2]. Until recently, this was accomplished through active or passive surveillance mechanisms. Passive surveillance is the

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traditional form of public health monitoring, and it relies on reporting of diseases by health care providers and laboratories to local or state health departments. Active surveillance entails active case finding by health department staff, with regular telephone or on-site visits to obtain information on new cases of notifiable diseases [3].

Syndromic surveillance has grown out of the appreciation that features of new or nonspecific conditions (eg, influenza or norovirus) may not be detected or are difficult to monitor with existing strategies [4]. Targeted active surveillance has been used to monitor special events (eg, athletic competitions and political conventions), but this is expensive and not sustainable [5,6]. Syndromic surveillance refers to the real-time monitoring of clinical syndromes, rather than specific disease etiologies [3]. This approach has received attention as a potentially rapid, economical, and flexible supplement to ongoing traditional surveillance activity [7]. Syndromic surveillance is now used as a part of routine public health monitoring in many local and state health departments [8]. This activity has proven value for monitoring citywide and regional trends of community-wide illness, such as influenza [9], but its ability to detect clusters of illness is less clear.

Despite growing interest in this area, there have been few prospective evaluations of syndromic surveillance efficacy. Hospital-based drills are one way to test these systems based on emergency department visit or hospital admission data and are capable of identifying both logistic shortcomings and limitations in the outbreak detection algorithms used to detect clusters. Next to actual events, these simulations are probably the most realistic way of evaluating this monitoring. Unlike computer models or simulations [10,11], drills challenge the communication chain from the moment a patient enters the health care system until an alert is relayed back to that and other facilities regarding the cluster of cases. Finally, drills can be conducted in a nearly blind fashion, with only the health care workers at individual facilities aware that artificial cases are being transmitted for analysis.

We describe a field simulation that was conducted using volunteers to assess the ability of 3 hospitals in a network to manage a large influx of patients with a potentially communicable disease. This drill provided the opportunity to evaluate the ability of the New York City Department of Health and Mental Hygiene's (NYC-DOHMH) emergency department chief complaint syndromic surveillance system to detect a small cluster of patients with febrile respiratory illness.

2. Methods

This evaluation was designed as a prospective simulation. Volunteers were recruited to visit the emergency departments of the 3 participating New York City area hospitals. The chief complaint and history of present illness was scripted in advance, and there were specific rules of conduct. The clinical picture was modeled on severe acute respiratory syndrome (SARS) symptoms. Although most volunteer patients had SARS-like presentations, to make the drill more realistic for the clinical staff, some volunteers had non-SARS chief complaints. As such, although the clinical staff may have become aware that a drill was being conducted, the clinical presentations and complaints were not homogenous. In addition, none of the clinical or clerical staff working on the day of the drill was aware that syndromic surveillance was being evaluated through the exercise.

Data were sent electronically to the NYC-DOHMH twice per day, using standard protocols [4]. The NYC-DOHMH performs daily spatial cluster analysis on emergency department visits for selected syndromes at participating hospitals in New York City. The number of drill participants was estimated to exceed the number of excess cases typically observed in statistically significant respiratory syndrome clusters in the NYC-DOHMH system. A P value of less than .01 is used by the NYC-DOHMH as their threshold for investigation of an increased syndrome cluster.

2.1. Setting

The drill was conducted in 3 urban hospitals in Brooklyn, New York: Kings County Hospital, State University of New York (SUNY) Downstate, and Kingsbrook Jewish Hospital. Volunteer patients with fever and respiratory complaints presented to the adult and pediatric emergency departments of each hospital on the day of the drill. Kings County Hospital is a large pediatric and adult trauma center that has more than 120 000 emergency department visits each year. The SUNY Downstate is a large tertiary care facility with cardiac and transplant services that see more than 50 000 emergency department visits each year. Kingsbrook Jewish Hospital is a secondary care facility that has a large nursing home referral base, with more than 20 000 emergency department visits annually.

2.2. Selection of participants

All patient participants in the drill were volunteers.

2.3. Drill Format

Volunteers were triaged and registered at all 3 hospitals according to each hospital's existing protocols. The number of patients assigned to each hospital was decided based on emergency department volume: Kings County was assigned 23 patients; SUNY Downstate, 11 patients; and Kingsbrook, 10 patients. Initially, a triage nurse handwrote each patient's chief complaint on a document that became part of the medical record. Later, at the time of disposition, a clerk transferred the handwritten information into the hospital's electronic registration database. Chief complaint and demographic information was extracted from the hospital

information system and transmitted to the NYC-DOHMH twice daily via the Public Health Information Network Messaging System, software promulgated by the Centers for Disease Control and Prevention for the secure transmission of patient information [12]. The drill was observed by the NYC-DOHMH, New York City Mayor's Office of Emergency Management, New York Emergency Management Services, the Greater New York Hospital Association, and the New York Health and Hospitals Corporation. The emergency departments of the 3 hospitals had their standard daytime staffing model in place on the day of the drill. The NYC-DOHMH syndromic surveillance analysts were not informed that a drill was being conducted. The drill was funded and supported by the NYC-DOHMH.

2.4. Primary data analysis

The day after the drill, routine daily analysis was conducted by the NYC-DOHMH on data from all 46 participating hospitals, including the 3 drill hospitals. Analysis included evaluation of citywide temporal trends and spatial clustering by hospital address or patient's residential zip code [4]. The purely spatial scan statistic used by NYC-DOHMH evaluates the ratio of syndrome visits (eg, fever visits) to other emergency department visits. Analyses were carried out using SAS version 8.0 (SAS, Cary, NC). In addition to the electronic files routinely generated and transmitted to the NYC-DOHMH, data were also obtained from the medical records of drill participants. These records were abstracted by a member of the research team for the purpose of comparison with the electronic records received by the NYC-DOHMH.

3. Results

Forty-four volunteers participated in the drill conducted on January 19, 2005, as mock patients. Thirty (68%) of the 44 volunteer patients were scripted to have a chief complaint of fever and cough. The chief complaint recorded by the triage nurse indicated fever and cough for 29 (97%) of these 30 patients, whereas the electronic chief complaint entered into the hospital registration system by registration clerks indicated fever and cough for 24 (80%) of the 30. The drill patients had a scripted epidemiological link to a recent skiing trip in Canada. Nonfever and noncough scripted chief complaints included chest pain, asthma, and minor trauma.

Records from 42 patients (95%) were successfully transmitted to the NYC-DOHMH; 2 drill patients were not entered into the electronic registration system. The 30 patients with fever and respiratory symptoms did not generate a statistically significant signal in the purely spatial scan statistic analysis at the NYC-DOHMH.

The age range of patients transmitted to the NYC-DOHMH was 10 to 80 years, with a median age of 17 years (interquartile range, 14-40 years). The 42 drill patients were classified in 8 categories by NYC-DOHMH based on the chief complaints that were entered into the registration system by hospital staff: sepsis (2), cold (3), respiratory (20), diarrhea (2), fever/flu (4), vomiting (3), and other (8). These categories are hierarchical in the order listed, so that a patient whose chief complaint was "cold, runny nose, cough, and fever" would be classified in the cold syndrome category, not the respiratory or fever syndrome category. Patients are further subdivided into age groupings. The main daily analysis of the NYC-DOHMH examines trends in respiratory and fever syndromes among patients aged 13 years and older and diarrhea and vomiting syndromes in patients of all ages. Using these parameters, 19 (63%) of the 30 patients who complained of fever and cough were included in the respiratory syndrome cluster analysis, and 4 (13%) were included in the fever syndrome cluster analysis.

The most likely cluster identified by a hospital-based spatial scan statistic analysis detected an increase in respiratory visits of patients aged 13 years and older at 9 Brooklyn hospitals, including the 3 drill hospitals and 6 others. One hundred twenty-eight visits were observed compared with 94 expected, with the largest number of excess cases occurring at Kings County (31 observed − 17 expected = 14 excess visits, of which, 9 were drill patients). However, with a P value of .037, this cluster did not meet the NYC-DOHMH threshold for investigation ($P < .01$). Similarly, analysis by patient's home zip code detected a borderline cluster in the zip code in which all 3 hospitals are located. The number of respiratory visits, although elevated on the day of the drill in the area of the 3 hospitals, did not appear particularly unusual when compared with the 14-day baseline period used by NYC-DOHMH spatial analyses (Fig. 1).

4. Discussion

The NYC-DOHMH conducts syndromic surveillance in 46 hospital emergency departments in the 5 boroughs of New York City [8]. The information is used to monitor citywide trends in seasonal diseases, such as influenza and norovirus, as well as to detect disease clusters that may signal localized outbreaks that are due to either natural epidemics or the intentional release of biologic agents [13]. This drill confirmed that emergency department chief complaint data can be electronically transmitted with a high success rate (95%), even in systems where triage data are handwritten.

The exercise also highlighted several challenges to syndromic surveillance monitoring. Despite using what was thought to be a sufficient number of drill patients in the respiratory and fever syndrome group, our exercise did not generate an investigation signal at the NYC-DOHMH. Retrospective review of the data from that day suggests that the drill cases were diluted by the high baseline level of fever

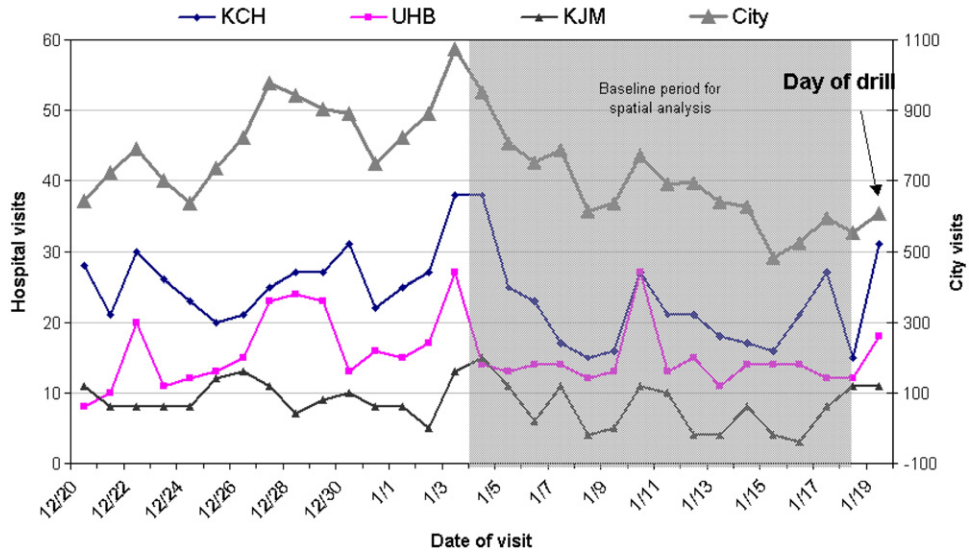

Fig. 1 Emergency department respiratory syndrome visits of patients aged 13 years or older during the month before January 19, 2005 (ED preparedness drill at 3 participating hospitals and citywide).

and respiratory visits at the 3 hospitals. In addition, despite explicit scripts and rules of conduct, the chief complaints of 6 patients (20%) did not result in assignment to the targeted syndrome group. The 6 SARS patients were misclassified in 3 categories: other (n = 3), sepsis (n = 2), and cold (n = 1). For 5 of the 6, misclassification was the result of incomplete information in the electronic chief complaint. That is, information collected by the triage nurse would have resulted in assignment to the appropriate syndromic group, but incomplete data entry by clerical staff resulted in misclassification. For 1 of the 6, misclassification occurred when the hierarchical syndrome coding algorithm used by the NYC-DOHMH classified "runny nose" into the cold syndrome category, despite the presence of text strings "cough" and "fever" in the chief complaint. Further details on these 6 patients are shown in Table 1. Other authors have described the impact of different methods used to group data into syndromic categories [14].

Another reason why our exercise did not trigger an alarm could have been how age is stratified in the detection algorithm. The median age of mock patients in the drill was 17 years. The NYC-DOHMH uses 2 age groups: less than 13 and 13 and older. For this reason, many of the younger drill patients were included in the adult age group. If alternative or multiple age groups were used, it is possible that our exercise would have generated a signal. However, much like changing the threshold for cluster detection, this could also have the effect of increasing the number of signals that would need to be investigated. Continued research is needed to optimize the detection algorithms for identifying clusters that may represent a disease outbreak [14].

Drills likely offer the most realistic opportunity to evaluate a syndromic surveillance system based at a clinical setting; however, there are still limitations to this approach. Hospital staff are necessarily aware of an ongoing exercise on the day of the drill. This awareness could have skewed isolation practices and biased case finding, resulting in different triage documentation for drill patients. Alternatively, it is possible that, in a busy emergency department, the volunteer patients may not have received the same intensity of medical attention as their real counterparts, as they did not appear to be ill and were not able to realistically simulate sick patients. For this reason, the drill could have underestimated the capacity of the emergency departments to correctly

Table 1

Patient	Age (y)	Blood pressure	Heart rate	Respiratory rate	Temperature (°F)	Sat (%)	Nursing chief complaint	Electronic chief complaint	Syndrome group
1	41	139/72	78	16	102.8	98	Cough, fever, chills for 2 days	Unresponsive	Sepsis
2		110/70	115	50		84	Patient unresponsive/respiratory distress	Unresponsive	Sepsis
3	16	122/79	89	14	97.8	100	Chest pain, cough	Chest pain	Other
4	15	110/79	90	16	98	98	Headache, cough for 4 days	Headache	Other
5	18	123/67	70	16	99	99	Headache, cough, fever for 5 days	Headache	Other
6	17	109/59	75	20	98.7	98	Cough, fever, runny nose, body ache for 3 days	Cough, fever, runny nose	Cold

record clinical symptoms in the triage log and registration system. Both of these factors may contribute to a lack of accuracy in the electronic chief complaints, which could then translate into misclassification of individual cases by the NYC-DOHMH. In addition, drills and simulations do not take account of the notification efforts of individual health care workers. As was the case in our drill, a clear epidemiological link existed between the participants. In a real outbreak, an astute health care worker would hopefully notify the local department of health directly. Furthermore, even if the drill had generated a signal from the NYC-DOHMH, it would not have been recognized until the data were analyzed the next day. Syndromic surveillance is not intended as a replacement for traditional provider-based reporting of unusual disease manifestations or clusters.

Syndromic surveillance is a fast, inexpensive, and flexible adjunct to traditional public health monitoring. As currently designed and used, however, these systems may not be sensitive enough to detect smaller syndrome clusters. Using information from drills and computer simulations, refinements in these networks may improve them and lead to better detection of distributed and smaller clusters. Notifications from health care workers will always play a major role in the identification of outbreaks, but new detection mechanisms like syndromic surveillance could generate supplementary information streams to augment ongoing public health activities.

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