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ABSTRACTS

SECTION I: SYNDROMIC SURVEILLANCE USING EMERGENCY DEPARTMENT DATA

Syndromic Surveillance for Bioterrorism: a System for Rapid Detection of Influenzalike Illness and Bioterrorism-Related Outbreaks

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The prodrome of several potential bioterrorism diseases will likely present as influenza-like illness. In a bioterrorism event, the window of opportunity for initiating effective postexposure prophylaxis is short. Real-time, syndrome-based surveillance mechanisms are needed. HealthPartners Medical Group (HPMG) delivers primary care to 240,000 persons in the Minneapolis/St. Paul metropolitan area in Minnesota. Patient encounter data, including *International Classification of Diseases, 9th Revision* (*ICD-9*) codes are entered rapidly into their database. Nonidentifying demographic and *ICD-9* data are sent to the Minnesota Department of Health (MDH) after posting to an HPMG database. Data are automatically extracted daily and sent to a secure MDH server. Data are appended to 3 years of HPMG *ICD-9* count data and analyzed using an outbreak detection algorithm designed specifically by MDH for bioterrorism surveillance. The algorithm normalizes the data using a regression model adjusted for day of the week, season, holidays, and autocorrelation. Cumulative sum (CUSUM) analysis of the predictive residuals is used to detect unexpected *ICD-9* count increases. The detection system triggers an "alarm" if the daily *ICD-9* count exceeds a threshold. The HPMG *ICD-9* data set was independently validated by comparison with historical metropolitan area influenza and pneumonia deaths. The regression model adequately controlled for *ICD-9* variability associated with weekend counts and seasonal influenzalike illness fluctuations. The system detected an influenza A outbreak that began in December 2000. When the system was "spiked" with data from a 1979 inhalation anthrax outbreak, it rapidly triggered an alarm. Detection of a bioterrorism event is possible, and real-time syndromic surveillance is achievable using existing data sets. This system was developed quickly and inexpensively.

Use of an Electronic Emergency Department Information System as a Data Source for Respiratory Syndrome Surveillance

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Emergency department (ED) syndromic surveillance may provide early warning of outbreaks due to bioterrorism or natural phenomena. We explored adapting an electronic ED information system (EmSTAT) for use as a data source for respiratory syndrome surveillance. After examining the flow of data in the system, we selected a subset of data elements

with potential epidemiological value and evaluated the elements for completeness and validity. Diagnosis codes, disposition, and demographic data were relatively complete; additional clinical data were less reliably recorded. Chief complaint codes were insensitive indicators of visits for respiratory syndromes; however, diagnosis codes correlated well with clinical data. A descriptive analysis of ED visits for respiratory syndromes was possible using diagnosis codes to define syndromes. Encrypted data were transmitted every 4 hours to the health department without added work for ED personnel. Adaptation of existing ED information systems such as this can provide rapid, reliable data for syndromic surveillance.

Partial Evaluation of a Drop-in Bioterrorism Surveillance System in Phoenix, Arizona

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The Maricopa County Department of Public Health (MCDPH), Arizona Department of Health Services, and the Centers for Disease Control and Prevention implemented a drop-in syndrome surveillance system in 11 hospitals in Phoenix, Arizona, in October/November 2001. The system captured 83% of all 37,157 patients entering the emergency departments, and 83% of these had syndrome information completed. This evaluation of the surveillance system has two components: (1) 33 interviews among participating hospital staff to determine acceptance of the system and (2) a comparison of entered data to paper forms to determine data entry quality. Findings from the data entry analysis showed that 22% of the 3,175 entries analyzed had at least one variable missing or entered incorrectly. Error rates for individual variables ranged from 1.3% to 13.4%. In hospital staff interviews, both positive and negative aspects of the system were mentioned. Positives of the system included willingness to participate again, heightened awareness of bioterrorism, ability to generate instant reports, and improved relationship between health departments and hospitals. Negatives mentioned by staff were that the system slowed the emergency department flow and was labor intensive; medical staff were not compliant; the syndrome checklist did not provide appropriate selections; paper forms were lost, incomplete, or skipped for some patients; and there were problems with the data entry system. We recommend more training for health care providers, incorporating the surveillance system into the existing routine ED electronic system (to reduce paperwork and increase compliance), providing better definitions of syndromes, and maintaining relationships between hospitals and health departments.

New Hampshire Emergency Department Syndromic Surveillance System

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In response to the terrorist attacks in 2001, the Bureau of Communicable Disease Surveillance (BCDS) in New Hampshire initiated emergency department (ED)–based syndromic surveillance in 16 sentinel hospitals based on geographic location and daily census. This sample covers 59% of the state's total ED visits. The syndromic categories collected include fever, respiratory conditions, gastrointestinal illness, and rashes. It is believed that monitoring these syndromes allows for detection during the early phase of a disease outbreak, either natural or resulting from bioterrorism. Participating hospitals send data by fax, phone, or e-mail; however, a pilot project for Web-based data entry is in process. Data are manually

entered by the BCDS into a database and analyzed using descriptive statistics and graphing techniques. Daily values are analyzed using a variation of the Shewhart control chart method. Graphs have four components: (1) daily data plotted for each syndrome, (2) an average of all values plotted to date, (3) upper and lower confidence levels (99.7%) for the average, and (4) upper statistical control limits (99.7%) for daily data. Approximately two or three triggered investigations occur per week. Data from 12 of the 16 hospitals showed a significant trend in fevers during February 2002, mirroring data from the state's Influenza Sentinel Surveillance Network during the same weeks. Several of the hospitals also showed an increase in rashes in the summer that corresponded to poison ivy and Rhus dermatitis season. No large-scale community outbreaks have occurred since the system's inception to test its ability to detect naturally occurring outbreaks.

Identification and Investigation of Disease Outbreaks by ESSENCE

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The Department of Defense Global Emerging Infections System (DoD-GEIS) has developed a prototype system for the early detection of infectious disease outbreaks at military treatment facilities. The Electronic Surveillance System for the Early Notification of Community-Based Epidemics, or ESSENCE, was implemented in 1999 as a pilot project for military sites within the National Capital Area, which encompasses Virginia, parts of Maryland, and the District of Columbia. It monitors illnesses by grouping similar *International Classification of Diseases, 9th Revision, Clinical Modification* (*ICD-9-CM*) codes into seven syndromes. Data collection begins with the provider completing the standard ambulatory data record. These data are coded through an interface of the Composite Healthcare System and then transmitted to a centralized server. They are then downloaded to the ESSENCE Web site and updated several times a day. Statistical tools using autoregressive analysis and Global Information System mapping indicate how abnormal a particular clinic day may be when compared to the previous 6 weeks of data for the same day of the week. These tools are used to prioritize the clinics from most to least aberrant within each of the seven syndrome groups. We show examples of how this surveillance system has detected several outbreaks, including simultaneous occurrences at different medical treatment facilities. Some of the outbreaks detected were the result of miscoding. We also show how this system has led to more accurate reporting of Ambulatory Data System information.

The Biosurveillance Analysis, Feedback, Evaluation, and Response (B-SAFER) System

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B-SAFER (Biosurveillance Analysis, Feedback, Evaluation, and Response) is a surveillance information system to collect health information from a variety of sources and analyze the data for conditions, including bioterrorism, that may be of public health concern. The following information is collected within 24–36 hours: clinical data elements from 6 of 8 local emergency departments (EDs) and from emergency medical services (EMS) reports; admission, discharge, and transfer logs (chief complaints and demographics); hospital utilization data; calls to the regional poison center for drug information; laboratory test requests;

and syndromic infectious disease surveillance reports from the state medical examiner's office. We encrypt unique identifiers at the originating institution to protect patient privacy. A medical epidemiologist from the state health department reviews data displays daily and investigates reports. Personal health identifiers can be obtained from the originating institution under state reporting requirements. Illnesses or events are reported from B-SAFER to the health department. We use a distributed, Web-based information system with an industry standard architecture (OpenEMed), compatible with NEDSS. The security infrastructure used enables systems with diverse security infrastructures to provide data to the system with strong encryption and full mutual authentication and authorization of all the clients and servers involved. Data elements are analyzed as received by both fixed and ad hoc rule-based algorithms and anomaly detection. This provides the opportunity to find new or unexpected clinical associations. Syndromic data are subject to natural language processing and statistical analysis based on historical baseline data. Evaluation and validation include sensitivity analysis for real and modeled outbreak identification and impact on response.

Syndromic Surveillance From Free-Text Triage Chief Complaints

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Preexisting electronic data may be useful for computerized syndromic surveillance. One of the earliest and most ubiquitous sources of clinical data is the triage chief complaint (TCC); however, TCCs are in free-text format and cannot be manipulated by computers. We have begun evaluating the usefulness of free-text TCCs in a computerized syndromic surveillance system called the Real-Time Outbreak Detection System (RODS) by testing (1) our ability to categorize automatically TCCs into syndromes and (2) the ability of free-text TCCs to predict cases of acute infectious gastrointestinal (GI) syndrome. Two statistically based text processing systems have been created and tested at classifying free-text TCCs into one of eight syndromes (respiratory, GI, neurological, constitutional, botulinic, rash, hemorrhagic, and other) monitored by RODS. We used one of the text processing systems to classify TCCs from randomly selected patients admitted to the emergency department in 2001 and measured its ability against that of *International Classification of Diseases, 9th Revision* (*ICD-9*) codes at detecting patients with acute infectious GI syndrome. The text classification systems classified free-text TCCs, with areas under the ROC curve ranging from 0.90 to 1.0. Using automatically classified TCCs, we detected cases of acute infectious GI syndrome with a sensitivity of 0.63 and specificity of 0.94. Using *ICD-9* codes instead of TCCs yielded a sensitivity of 0.32 and a specificity of 0.99. In spite of the limited amount of information in a TCC, we can accurately classify the TCCs into syndromes and can identify actual cases of acute infectious GI disorder with fairly good results.

Real-Time Biosurveillance Using an Existing Emergency Department Electronic Medical Record Database

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In part because of recent bioterrorism events in this country, there is increased interest in the use of existing databases to provide early warning of bioterror attacks. We wished to determine if an existing emergency department (ED) electronic medical record database has the potential to track disease patterns, including bioterrorism events, in real time. The design was retrospective analysis of a computerized database of ED visits. The setting was 15 New

Jersey EDs, with participants consecutive patients seen by ED physicians January 1998 through July 2002. Based on *ICD-9* codes, syndromic groups were developed for the following categories: any gastrointestinal, diarrhea, respiratory, asthma, chest pain, fever, skin, headache, and weakness. We then generated daily counts of patients by category and generated time series graphs to display the incidence of disease for these syndromic groups over the 4.5-year period. We also generated similar counts and graphs for the same syndromic groups based on the physician's choice of charting template rather than *ICD-9* code and compared the results. There were 3.2 million patient visits in the database. Visual inspection of the time series graphs showed definite seasonal peaks in the diarrhea, respiratory, asthma, fever, and skin syndromic groups. There was good agreement between *ICD-9* codes and templates. The existing ED database identified seasonal peaks in the incidence of several disease syndromes. Tracking physician charting template usage could potentially identify these patterns in real time. This ED database may be able to provide early warning of disease outbreaks and some types of bioterrorist attacks.

The Use of Hospital Emergency Department Chief Complaint Data as a "Near" Real-Time Marker for Assessing Public Health Risk of Infectious Disease Outbreak

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Since September 11, 2001, and the corresponding anthrax attacks, there has been considerable interest in developing pre-event surveillance methods that would be used for early detection of a bioterrorist event and prevention of widespread morbidity and mortality. Traditionally, active surveillance mechanisms to detect disease outbreaks consist of confirmatory laboratory testing after preliminary diagnosis from a physician. In many cases, the confirmation of infectious disease takes days of testing, many hours of epidemiological analysis, and significant public health resources at the local level before an outbreak is finally diagnosed. Our communities are at significant risk unless public health authorities can develop a pre-event early warning system with a high degree of specificity and sensitivity for outbreak detection when patients present themselves to the emergency department or their primary health care provider. A pre-event early warning system depends on quality, "near" real-time data from the medical community. Potential sources of this information are (1) hospital emergency department encounters, (2) outpatient clinic visits, (3) pharmacy data (over the counter and prescription). All data sources have varying degrees of quality, but the hospital emergency department registration information (chief complaint at initial visit) is determined to provide the nearest real-time means for use in a pre-event surveillance system. But, is chief complaint information as reliable as *International Classification of Diseases, 9th Revision* (*ICD-9*)–coded discharge diagnosis in predicting an early event? *ICD-9* diagnosis is considered to be the best indicator of patient diagnosis, but is not readily available for epidemiological analysis until 3 to 5 days after initial visit. The New York State Department of Health and Emergency Medical Associates of New Jersey Research Foundation (EMARF) have completed a study comparing emergency department chief complaint data with *ICD-9* discharge codes from 2.7 million patient encounters presenting to 15 emergency departments in New Jersey to determine the feasibility of using chief complaint for pre-event surveillance. Preliminary findings show a high specificity and sensitivity comparing chief complaint data to *ICD-9*-coded discharge diagnosis.

Connecticut Hospital Admissions Syndromic Surveillance

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Responding to the events of September 11, 2001, the Connecticut Department of Public Health initiated a daily hospital admissions syndromic surveillance (HASS) reporting system. Each of the 31 acute care hospitals statewide were required to report the number of the preceding day's nonscheduled admissions; these were categorized by admission diagnosis into 11 different syndromes, including pneumonia, hemoptysis, respiratory, neurologic, nontraumatic paralysis, sepsis and nontraumatic shock, fever with rash, fever of unknown cause, gastrointestinal, skin infection, and clusters of illness. From November 2001 through July 2002, the average number of unscheduled admissions per million population per week and range per week for each syndrome was as follows: pneumonia 93.2 (35–147), hemoptysis 1.2 (0–3.2), respiratory 12.5 (1.2–21.8), neurologic 2.2 (0.3–5.3), nontraumatic paralysis 1.2 (0–4.1), sepsis and nontraumatic shock 17.4 (12–22), fever with rash 0.9 (0–2.1), fever of unknown cause 10.3 (5.6–16.2), gastrointestinal 26.8 (11–37), skin infection 0.1 (0–0.9), and clusters of illness 0.4 (0–3.5). A total of 18 possible outbreaks were detected, including 9 pneumonia, 3 skin infections, 2 respiratory, 2 gastrointestinal, 1 hemoptysis, and 1 paralysis. There were 6 additional "pseudo-outbreaks" that, on investigation, were rapidly determined to be the result of data entry error by the hospitals. The baseline weekly rates were low enough to be sensitive to moderate increases in the rate of admission, and admissions for pneumonia, gastrointestinal illness, and sepsis were the most common. Comparison with similar data from other systems and validation of the data obtained is needed to determine better the ongoing utility of this system.

A Comparison of Syndromic Incidence Data Collected by Triage Nurses in Santa Clara County With Regional Infectious Disease Data

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We compared data from a syndromic surveillance system for the early detection of bioterrorism-related illness with regional infectious disease data to estimate the surveillance characteristics of the syndromic data. Since October 2001, nurses in 12 emergency departments and 1 telephone care center in Santa Clara County, California, have recorded whether each patient triaged has none, one, or more than one of six clinical syndromes associated with bioterrorism-related illnesses (e.g., influenzalike symptoms, fever with mental status changes, and acute respiratory distress). Triage nurses fax or e-mail the syndromic data to the health department at the end of each shift; the data are analyzed and distributed to public health officials. Over the first 302 days of data collection, triage nurses reported data on 307,684 patients. Numerous daily counts in excess of 3 standard deviations above the mean were investigated, but did not result in the identification of previously unknown disease outbreaks. Only the influenzalike illness syndromic data demonstrated a discrete outbreak. We compared these data to state influenza surveillance data. The slope of the influenzalike illness syndromic data first deviated from its baseline the week of January 20 and reached its maximum during week of February 17—the same weeks that the state surveillance data first detected the influenza outbreak and reached its peak. We concluded that a syndromic surveillance system based on triage nurses could detect influenzalike illness with timeliness and sensitivity similar to traditional infectious disease surveillance data. Whether this syndromic surveillance system can detect bioterrorism-related illness is unknown.

Using Existing Electronic Hospital Data for Syndromic Surveillance

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Obstacles to syndromic surveillance include the need to secure the cooperation of diverse health care systems, the lack of standardization of electronically stored data, the financial costs of data acquisition and manual entry, and the legal issues related to confidentiality. We developed an approach that uses daily imports of ADT (admission, discharge, and transfer) and LIS (laboratory information system) data, in essentially their native format, from a wide variety of system vendors. Data are presented for a university hospital for September 15, 2001 through September 15, 2002. Data were plotted using statistical process control methods (UCL = 3σ). For the 1-year period under study, there were 73,910 emergency department (ED) visits. ED visits with orders pertaining to the respiratory test (e.g., virus screens) showed discrete episodes exceeding the UCL and corresponded to a cluster of patients who tested positive for influenza. Similarly, a peak in ED visits with stool test orders corresponded to a cluster of patients who tested positive for *Shigella spp*. These results suggest that syndromic measures based on visit and testing data can be done with existing electronic data. Using data from hospitals without requiring data formatting to external standards substantially reduced disincentives to hospital participation. We provided daily feedback to infection control, which gave hospitals a real incentive to participate. Sending notifiable disease (with identifiers) and other data to local or state health departments (without identifiers, but with duplicates removed) would be a simple extension of this approach.

SECTION II: EVENT-BASED SYNDROMIC SURVEILLANCE SYSTEMS

Web-Based Japanese Syndromic Surveillance for FIFA World Cup 2002

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Web-based syndromic surveillance for the 2002 FIFA World Cup was performed successfully with 11 jurisdictions throughout Japan for 2 months. No major outbreaks were detected by syndromic or by strengthened routine surveillance. However, an aseptic meningitis epidemic was first detected as a "neurological syndrome." Surveillance was conducted with 87 hospitals in Tokyo and the 10 prefectures hosting soccer games. Information was collected and distributed using the Emergency Medical Information System, a preexisting national Web-based system. Hospitals accessed this Web site and submitted the data daily before noon. Reporting criteria were hospital admissions in which infection was either suspected or confirmed. There were five case classifications: (1) cutaneous, mucous membrane, or bleeding disorders; (2) respiratory; (3) gastrointestinal; (4) neurological; and (5) nonspecific syndromes. Each local health authority was responsible for monitoring its own surveillance data and taking action as needed. The National Institute of Infectious Diseases supervised the response of the prefectural health authorities and monitored data for diffuse outbreaks. Feedback information included daily status reports and outbreak information submitted by local and national health authorities. A total of 3,444 cases were reported, and the hospitals sustained a high reporting rate throughout the surveillance period. Web-based syndromic surveillance over a limited period of time appears to be both feasible and effective, even when surveillance sites were over all of Japan. To improve this system, an evaluation, including a questionnaire study, is now ongoing.