earlier versus later, respectively. No significant deviations were observed using CUSUM methods. We found higher ED-based respiratory-related chief complaints rates during a time of intense forest fire activity near Denver. UC visit rates for asthma were decreased compared to the prior period. Public health information alerts may have played a role in decreasing exposure and avoiding increased HCU.

Milwaukee Biosurveillance Project: Real-Time Syndromic Surveillance Using Secure Regional Internet

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Milwaukee, Wisconsin, was visited by 1.2 million people for events, including the All Star baseball game, in July 2002. Eight emergency departments (EDs), four primary/urgent care practices, and one medical examiner reported, using existing personnel, syndromes associated with bioterrorism agents to the Milwaukee Health Department daily for 4 weeks. Clinicians were to complete a brief symptom checklist during each patient encounter. In practice, some EDs screened only selected patients, and many supplemented clinician reports with log reviews. Daily ED syndrome and total visit volume reports were collected and displayed using the EMSystem secure Web site. Patient-identifying information was not sent to the Milwaukee Health Department, but was retained at the ED in case needed. Participating EDs were visited by 26,888 patients, and 314 patients were reported to meet syndrome criteria over the 4 weeks. The rate of syndrome cases to total visits ranged from 0.04% to 2.8% across the various EDs; EDs that relied exclusively on physician checklists had lower syndrome-to-visit rates. Mean ED administrator ratings of implementation and reporting ease ranged from neutral to modestly positive. They negatively rated the ease of clinician involvement. Mean clinician ratings of their experience were neutral to modestly negative. Estimated added patient time in ED averaged less than 4 minutes. Estimated total additional staff time per patient approximated 10 minutes. Primary care practices reported a higher syndrome rate (8.8% of 2,442 visits), which included a camp-associated cluster of streptococcal pharyngitis. A Web-mounted "dashboard" facilitated comparison of syndrome rates and other surveillance trends. The Web site facilitated collection, analysis, and display of surveillance information.

SECTION III: DATA TRANSFER AND TRANSFORMATION

The Frontlines of Medicine Project: a Proposal for the Standardized Communication of Emergency Department Data for Public Health Uses Including Syndromic Surveillance for Biological and Chemical Terrorism

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The nation's emergency departments (EDs) are a potential source of surveillance information. The Frontlines of Medicine Project is a collaborative effort of emergency medicine, public health, emergency government, law enforcement, and informatics to develop nonproprietary, standardized methods for reporting emergency department patient data. An initial proposal, published in April 2002, proposed a standardized message structure based on XML (Extensible Markup Language) for reporting triage information from emergency departments to regional surveillance centers and called for reader comments. Subsequently, a consensus conference, with attendees chosen through a modified nominal consensus process, was held to discuss the initial Frontlines proposal and provide recommendations for next steps. Since the consensus conference, an Internet-based Delphi survey technique has been used to refine further the Frontlines recommendations. The technique was utilized for two rounds to yield a consensus exceeding 75% acceptance of the proposed data elements and preferred *International Classification of Diseases, 9th Revision* (*ICD-9*)–coded chief complaint values. The data elements for the triage surveillance report include provider facility ID, patient ID, encounter ID, patient age, age unit, gender, date/time first documented in ED, date/time symptom onset, chief complaint, first ED responsiveness assessment, first ED systolic blood pressure, first ED diastolic blood pressure, first ED heart rate, first ED temperature, ED temperature unit, and ZIP codes for home, work, and incident site. The preferred chief complaint categories include 159 complaints arranged in 16 hierarchical categories that are expected to describe the reason for visit in greater than 99% of ED encounters. Further details are available at www.frontlinesmed.org.

Foodborne Outbreak Early Detection System (FOEDS)

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The FOEDS (Foodborne Outbreak Early Detection System) Forum (www.RUsick2.msu.edu) is a structured, Web-based forum that collects and shares data regarding a 4-day food history, food sources, animal contact, and other risk factors that are helpful in establishing the existence of a time-space cluster of possible foodborne origin. It is a syndromic surveillance system that allows users to search the database to evaluate the possibility that a group of people became sick with the same symptoms at about the same time after eating the same food from the same source. The FOEDS Forum is designed to identify suspicious time-space disease clusters that may, at the local health department's discretion, be worthy of further investigation. As such, it can be viewed as a "front end" to our current national system for identifying and investigating foodborne outbreaks. Data collection was scheduled to begin in October 2002 in the three-county area of Greater Lansing, Michigan. Clinic-based and population-based advertisements were to encourage people with suspected foodborne disease to visit the Web site to determine if they ate the same food that others ate before becoming ill with similar symptoms. Input screens and output reports will be presented, as will program implementation in the three-county pilot area. The FOEDS Forum was developed by epidemiologists from state and local governmental agencies and academic departments working under the umbrella of the National Food Safety and Toxicology Center at Michigan State University.

Conceptual Models: Definitions, Construction, and Applications in Public Health Surveillance

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Conceptual models are the core of robust classification schemes (e.g., SNOMED-RT, GALEN) and emerging standards for the exchange of health care information (e.g., HL-7). Conceptual models are defined here as a conceptualization, simplification, or abstraction of reality. Community surveillance activities involve representing information for sharing, and therefore they rely heavily on conceptual models. Conceptual models, either implicit or explicit, act to guide processes of information exchange and as the context for assimilating heterogeneous data. An explicit conceptual model is what guides aggregation of "units of information" and will be an essential component of successful surveillance systems. The Centers for Disease Control and Prevention has labeled conceptual data modeling as "one of the most powerful and effective analytical techniques ever developed for understanding and organizing information required to support any enterprise." There is little formal discussion about what constitutes strong conceptual models or a formal methodology for how they are constructed. This project examined qualitative data from two sources to develop a generalized methodology for constructing conceptual models. Narratives from the literature in various domains are explored, and these data were triangulated with content analysis from a case study. In this case study, domain experts reviewed and commented on a conceptual model designed to represent pediatric asthma knowledge. This triangulation of literature and expert reviews identified a generalized methodology for the construction and evaluation of conceptual models. In addition to the discussion of conceptual model development, this poster presents potential applications of conceptual models for data aggregation and manipulation critical to syndromic surveillance.

Tools to Facilitate the Interchange and Analysis of Nontraditional Health Surveillance Data

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The use of "nontraditional" health data, such as school absenteeism and pharmacy sales, is thought to increase the sensitivity and timeliness of warnings from syndromic surveillance systems. A common description scheme for nontraditional data and data sources will greatly increase the utility of such data. Standards such as those proposed in the National Electronic Disease Surveillance System and the Health Level 7 Reference Information Model enable interchange of traditional epidemiological and clinical data. Unfortunately, such standards were not designed to accommodate the needs of nontraditional data and their sources. To meet these needs, we have developed a flexible, extensible ontology (metadata model). Most data standards attempt to preenumerate fields and formats for every needed piece of information. However, it is not yet established which types of nontraditional data and metadata are necessary or useful. In addition, heterogeneity in the format and structure of nontraditional data makes it difficult to construct a single, comprehensive "standard." Instead, our ontology allows users to construct detailed, customized, machine-readable descriptions of data sources, data formats, and relationships between data sources by building them up from simple terms and attributes provided by the ontology. New classes of data or data sources, and individual instances of these classes, can be entered through an open source knowledge acquisition application. In an initial evaluation, we used the ontology to produce a model of output data from a simulated outbreak. We are continuing to validate the ontology as a

robust and extensible structure for rapidly characterizing, describing, and communicating nontraditional data.

A Knowledge-Based Approach to Defining Syndromes

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Syndromic surveillance can only produce meaningful results if there is a common understanding of what observations constitute a syndrome and consequently how a syndrome relates to diseases that may cause those observations. However, the constituent elements of syndromes, such as "flulike illness," are poorly characterized and rarely explicitly defined by surveillance system developers. We describe here a preliminary ontology for the creation of bioterrorism syndrome knowledge bases that will facilitate sharing and comparison of knowledge independent of a particular system or research group. In addition, we have created an inference heuristic problem-solving method that can relate indirect measurements of disease to diseases of interest. Our ontology enables precise enunciation of forms of evidence required to diagnose a syndrome. The ontology contains six major categories: syndrome, syndrome modifier, system affected, sign/symptom, direct supporting evidence, and indirect supporting evidence. We have instantiated the ontology for the syndrome "bioweapon respiratory illness." The inference heuristic can use the elements of this ontology to combine direct measurements into meaningful abstractions. Each sign and symptom has a defined, explicit relationship to supporting direct and indirect evidence, like measured temperature or a patient's chief complaint. Similarly, the presence of a syndrome can only be inferred if illness within requisite body systems can be substantiated by the presence of symptoms. We propose that all developers of syndromic surveillance systems explicitly define their syndrome concepts using a standard ontology. Syndrome definitions can be stored as instantiated knowledge bases in a common central repository, permitting knowledge sharing and reuse.

A Knowledge-Based Method for Surveillance

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Surveillance of prediagnostic "nontraditional" data sources (e.g., school absenteeism, pharmaceutical sales, emergency medical services calls) is expected to enhance the timeliness of epidemic detection. However, prediagnostic data are not as specific as diagnostic data, so multiple sources must be followed to reduce false-positive detections. Combined analysis of multiple nontraditional data sources requires knowledge about the relationships between data sources, but knowledge of these relationships is often qualitative and uncertain. Statistical methods perform well for focused analyses of quantitative data according to well-defined models. However, statistical models do not readily incorporate qualitative data and can become unwieldy as the number of parameters grows. A knowledge-based approach requires explicit representation of surveillance knowledge and tasks and enables knowledge to be applied to problem solving in a structured manner. Our research approach is to model the tasks involved in public health surveillance and the knowledge required to accomplish these tasks. Based on these models, we identify or develop problem-solving methods (PSMs) that accomplish surveillance tasks. This modular development approach enables controlled evaluation of different PSMs and knowledge representations in terms of epidemic detection and impact on decision making around interventions. Prototype methods have been implemented

for detection of syndromes in individuals using a heuristic approach, normalization using Kalman Filtering, and epidemic detection using a Gaussian Bayesian belief network. Based on our experience with these prototypes, we are beginning to formally model surveillance knowledge requirements, implement additional PSMs, and develop an evaluation framework.

SECTION IV: STATISTICAL METHODOLOGIES

A Cumulative Sum Approach to Syndromic Surveillance in Geographic Regions

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A primary objective of syndromic surveillance is to find as quickly as possible any significant increase in the rates of syndromes of interest. One way to achieve this is to use cumulative sum methods; such methods are commonly used in industry to detect unwanted changes in industrial processes, and they fall within the more general category of statistical process control methods. Cumulative sum (CUSUM) methods operate by accumulating deviations between observations and expectations. When these cumulated deviations exceed some predefined threshold, an alarm is sounded to indicate an increase in the mean of the underlying variable of interest. Daily data were available on the number of visits made by patients residing within given census tracts to clinicians in the Boston, Massachusetts, area for lower respiratory infections. Expected counts were modeled for the period 1996–1998 using logistic regression and using month, weekday/weekend, and a time trend as covariates. In general, weekends and summer months result in lower odds of office visits in comparison with weekdays and winter months. The observed counts were then compared with the expected counts using the cumulative sum method. The small daily counts suggest that a Poisson CUSUM be employed, for which the expectations vary over time. The method outlined can be extended to account for the fact that observed counts typically exhibit more variability than a Poisson model would suggest. The current approach detects increases in specific regions; a next step is to allow for the possibility that small clusters of geographic regions witness increases in rates.

An Elliptic Spatial Scan Statistic and Its Application to Breast Cancer Mortality Data in Northeastern United States

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The spatial scan statistic is commonly used for geographical cluster detection, cluster evaluation, and disease surveillance. Recent use includes daily analyses of syndromic emergency room data for the early detection of disease outbreaks in New York City. Whether an outbreak is due to a natural cause or a bioterrorism attack, this system enables city health officials to investigate the outbreak as early as possible and, if necessary, to rapidly implement disease prevention and control measures. When applying the spatial scan statistic, it is natural to use a circular scanning window to define the potential cluster areas since the circle is the most compact shape that can be obtained. Other shapes are also possible, such as