EVALUATION OF A PILOT EMERGENCY DEPARTMENT ELECTRONIC ASTHMA SURVEILLANCE SYSTEM

By

Leslie Davidoff, MS, MD

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CERTIFICATE OF APPROVAL

This is to certify that the MPH thesis of

Leslie Davidoff, MS, MD

has been approved

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ABSTRACT

Asthma, accepted by many to be an emerging epidemic, is a large public health burden. Morbidity is significant and financial costs are high. A substantial portion of the total public health cost for asthma is due to largely preventable emergency department (ED) visits. Epidemiologic data on these visits are limited, nationally and statewide. Data from a pilot ED electronic surveillance system, funded by the CDC, can augment our prior knowledge on incidence of acute asthma exacerbations and characterize the relevant demographics. The information obtained can be tracked over time, and has direct relevance for stakeholders designing preventive interventions and formulating policy.

Because this is a pilot surveillance system, its utility according to CDC criteria is unproven. I investigated how well the system fulfilled the nine CDC guidelines necessary for a useful surveillance system: simplicity, flexibility, acceptability, timeliness, stability, data quality, representativeness, sensitivity, and positive predictive value. I found that the system currently fails the test for utility primarily due to personnel instability and lack of financial acceptability. However, with resolution of these issues, the system would fulfill some of the CDC utility criteria: detection of diseases of public health importance in a timely fashion, and monitoring of trends in disease occurrence.

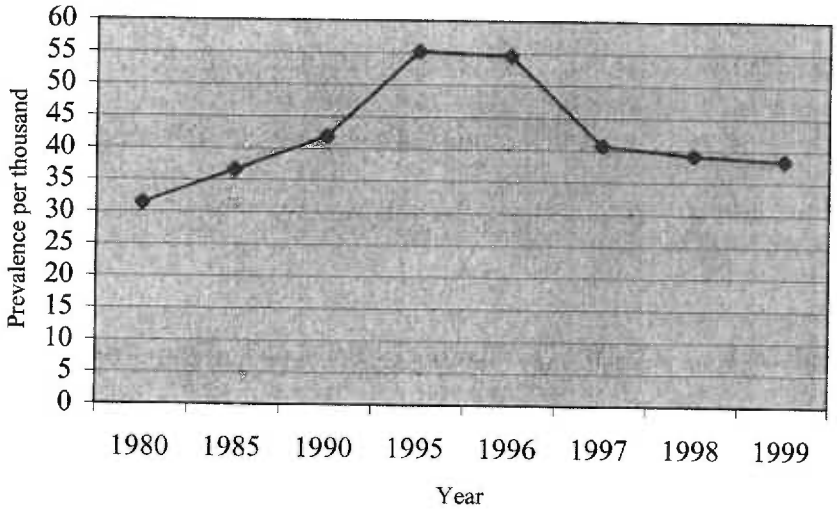
INTRODUCTION

Surveillance lays the groundwork for obtaining the public health information so critical for policy formation, assessment, and intervention. Because asthma is an important medical and public health problem, population-based data are invaluable. Current data on prevalence, incidence, and exacerbations are inadequate because they underestimate the numbers involved, and because methodological limitations compromise the validity of the diagnoses used in the estimates. A pilot surveillance system was set up to fulfill the need for more data on acute asthma exacerbations that are not subject to the same limitations. For my thesis, I elected to evaluate this pilot system using the most recent CDC guidelines.

Public Health Burden of Asthma

By 2001, an estimated 31.3 million persons reported ever having had asthma diagnosed, and 20.3 million persons, or 73/1000, were currently affected (1-2). Prevalence did not vary substantially among geographic regions (3). Figure 1 shows the gradual but consistent upward trend in 12-month asthma prevalence during 1980 to 1996. The National Health Interview Survey (NHIS) instituted major changes in the wording to their questions in 1997; therefore, the CDC feels that forming conclusions regarding the trend since that time is not yet possible (3).

Figure 1. Estimated Annual Prevalence of Asthma by Self-report; per 1000 Population: Age-adjusted to 2000 US Population - United States, National Health Interview Survey, 1980-1999.



The increased prevalence, now considered epidemic by many national health agencies, has generated significant concern (2-7). Table 1 shows that establishing asthma surveillance systems and reducing emergency department asthma visits have now become key components in the Healthy People 2010 objectives (3,8).

Table 1. Asthma Related Goals from Healthy People 2010

Reduce	
	Asthma related deaths, hospitalizations for asthma, hospital emergency room visits for asthma, and limitations among persons with asthma
	The number of school days or workdays missed because of asthma
Increase	
	The proportion of persons with asthma who receive formal patient education, including information about community and self-help resources, as an essential part of the management of their condition
	The proportion of persons with asthma who receive appropriate asthma care according to the NAEPP* guidelines
Establish	In at least 23 states a surveillance system for tracking asthma deaths, illness, disability, the impact of occupational and environmental factors on asthma, access to medical care, and asthma management

*National Asthma Education Prevention Program

In 2000, asthma caused 4, 487 deaths, and over 14 million days of school or work missed/year (1,9). Asthma costs now exceed the combined total for AIDS and TB, doubling from $6.2 billion in 1990 to $12.7 billion in 2000 (4,5,10). Direct costs totaled $8.1 billion, and a substantial portion was due to emergency department (ED) visits (1,6).

In 2000, the economic cost for ED visits alone exceeded $650 million, over double from $295 million a decade earlier (1,6). Because asthma is a chronic disease with largely preventable acute exacerbations, these ED costs could be markedly decreased with the proper medical management of asthma (11). The latter includes use of maintenance inhaled corticosteroids, known as "controller" medication, and supplementation by short periods of oral corticosteroids when necessary. Both have been shown to decrease asthma exacerbations (11-15,16).

In 2002, almost 2 million ED visits, or ~76/10,000, were for asthma (3-4,6,17, 18). Analysis of trends demonstrates that the age-adjusted rate of ED asthma visits is increasing steadily. From 1992-1999, the rate of ED asthma visits increased by almost 30% (3).

Like the rest of the nation, Oregon has experienced a steady increase in asthma prevalence. In 2001, Oregon was among the top 8 states in the country for prevalence, with current asthma estimated at 8.1% (2). Asthma was about twice as prevalent in women (11.3%) as in men (6.2%) (19). The annual rate of hospitalization for asthma in

Oregon in 2001 was 7/10,000; 9.4% of men and 3.8% of women were hospitalized overnight 1-2 times (19,20). The asthma death rate was 2/100,000 (20).

Most of the available data on asthma in the estimated 63,000 Oregon children affected are from the Multnomah Education Service District (MESD). According to school health forms completed by the parents, these children had an asthma prevalence rate of 7.2%. Asthma was reported slightly more often in boys (7.7%) than in girls (6.6%), and was most common in African American (10.9%) and American Indian (12.2%) children (20). Oregon does not yet have data on the prevalence of acute asthma exacerbations, exclusive of fatality or hospitalization, as will be discussed below.

Limitations of Prior Data Sources

Population-based data on asthma prevalence derive largely from two types of sources. The primary source for individuals is self-report data from the Behavioral Risk Factor Surveillance System (BRFSS), and the household-based National Health Interview Survey (NHIS). The National Hospital Ambulatory Medical Care Survey (NHAMCS) derives data primarily from ICD-9-CM based billing records of clinic and hospital encounters (3,18). There are significant drawbacks to these data sources used for prevalence estimates, as none use direct clinician diagnosis. The NHAMCS billing data are derived from clerical interpretation of visit encounters, designed to maximize reimbursement for the institution, and thus are subject to misclassification. The BRFSS and NHIS self-report data are subject to recall bias on the part of respondents, and interviewer bias on the part of personnel collecting the telephone information.

Prior data sources on asthma ED visits and severe asthma exacerbations have been limited. Until now, ongoing national asthma ED surveillance has been limited to cross-sectional emergency department visit data collected annually since 1992 by the NHAMCS (18,21). Localized asthma ED projects exist, but their methodology and focus are quite variable (22-27) and do not constitute surveillance projects.

Very recently, researchers described the development and evaluation of a prototype system for statewide asthma surveillance using hospital admissions data, ED/outpatient clinic records, physician surveys of diagnosis and treatment practices, and a community prevalence survey (28). This approach, while comprehensive, was not cost-effective. The authors commented that state health departments, or even lung associations, would be unable to afford the cost of such a surveillance system on a regular basis (28).

Thus far, the only Oregon ED visit data available to the Department of Human Services (DHS) derive from its Asthma Data Workgroup's (ADWG) analysis of ED visits in eight health plans and systems. The ADWG, now part of the Division of Health Promotion and Chronic Disease Prevention (HPCDP), uses two case definitions for asthma, modified from the Health Plan Employer Data and Information Set (HEDIS) technical specifications (29). Although the "current asthma" definition is broader than that from HEDIS, the ADWG felt it to be more comparable to information obtained from medical charts. The "persistent asthma" definition is claims-based, and reflects patients with either more severe asthma or poorly controlled asthma. For emergency department

services, only the ICD9-CM code 493 meets the work group criteria (29). Importantly, this analysis reflects only individuals aged 4-55 enrolled in a health care plan for a minimum of six months. It therefore does not represent Medicaid beneficiaries with shorter enrollments, or those who do not participate in a managed care plan. Additionally, no data are analyzed if the ICD-9-CM code is different than the above. For example, the analysis does not include "reactive airway disease" (519.9), "bronchospasm" (519.1), or "wheezing" (786.05). This restriction of the age range, the population studied, and the ICD-9-CM code inevitably misses cases. Ideally, state ED visit data should cover all ages, all individuals regardless of insurance status, and include other codes commonly used for asthma.

The Role of Electronic Surveillance Systems

Adequate surveillance requires that public health workers be able to accurately identify cases, have access to necessary data, and have adequate resources for collection, assessment, reporting, and use of data (30). Electronic surveillance has the capacity to provide certain advantages in this regard. Some consider it more efficient regarding timeliness, completeness, and resource utilization (30-33). It may also provide better geographic specificity (3). If enacted on a population basis, the data generated would be invaluable to elucidate the magnitude of the public health burden of poorly managed asthma, relevant demographics, and temporal trends.

It would also provide direction for development of preventive interventions recommended by the National Asthma Education & Prevention Program (NAEPP). The

NAEPP, which has convened several expert panels since 1991, attempts to present health care workers with comprehensive asthma guidelines, in order to bridge the gap between current knowledge and practice (11,34). One such gap often occurs in the arena of ED discharge treatment. In the NAEPP's Second Panel Report, (EPR-2), the guidelines for ED discharge treatment included a recommendation for prescribing 3-10 days of steroids, and referral to a follow-up medical appointment within 3-5 days (11). Electronic ED surveillance would permit us to identify overall compliance with those guidelines, as well as those subgroups at highest risk for noncompliance.

Study Objectives

Because this is a pilot project, its utility for surveillance of asthma is unproven. The CDC criteria for the utility of a surveillance system are given in Table 2 (35). The system is considered useful if it provides a satisfactory answer to at least one of these four questions.

Table 2. The Four CDC Utility Criteria

1. Does it detect diseases of public health importance in a timely fashion?
2. Does it provide estimates of the magnitude of morbidity?
3. Does it detect trends in disease occurrence?
4. Does it lead to improved clinical practices?

The system was originally designed to detect severe asthma exacerbations in a timely fashion, to provide an estimate of the magnitude of this problem, and to be able to detect annual trends. It therefore was intended to fulfill three of the utility criteria. It was not designed to improve clinical practice.

To fulfill these criteria, it would be reasonable to surmise that the surveillance system as a whole should possess the nine CDC-recommended attributes: simplicity, flexibility, data quality, acceptability, sensitivity, predictive value positive, representativeness, timeliness, and stability (35). I employed the updated CDC guidelines for surveillance systems as criteria for the evaluation. Not all of the guidelines were relevant to each purpose. Therefore, I evaluated whether the pilot surveillance system possessed each of the attributes that were relevant to the individual purposes, and those that were relevant to the overall system operation.

To evaluate the performance of the OHSU/DHS pilot electronic surveillance system for asthma ED visits my objectives were to:

- examine the performance of the overall system,
- investigate the system's ability to estimate the numbers of cases of emergency asthma visits,
- evaluate the system's ability to characterize patients' demographic characteristics, and
- evaluate the system's ability to provide data useful for future hypothesis testing, including those relevant to clinical quality control.

BACKGROUND

Purposes of the Pilot Surveillance System

In 2000, recognizing the value of using emergency departments to capture point-of-care information on asthma emergencies and fatalities, the CDC funded a program to implement asthma surveillance and interventions in hospital emergency departments (3). A pilot of this program was initiated at OHSU ED as part of this initiative to develop new methods of surveillance for asthma exacerbations. Asthma surveillance was added onto the previously existing infrastructure in place for electronic surveillance for pelvic inflammatory disease (PID). The information obtained through this pilot was designed to address a major gap in the data from Oregon's existing asthma surveillance system.

The project was originally intended to pilot a fully automated surveillance system for asthma exacerbations, sending batched data from an academic ED to a state health department in real-time. The surveillance system had two major purposes. The first purpose of the surveillance system was to provide an estimate of the numbers of patients visiting the OHSU ED for asthma exacerbations. Because OHSU only handles 7-9% of the ED visits in the county, the originators of the system did not expect these numbers to serve as anything more than an estimate of OHSU ED asthma patients. However, because these visits are an indicator of poorly managed asthma, such an estimate would provide a baseline with which the state could track the information over time, particularly with respect to the Medicaid and uninsured population. It would augment the information already used by DHS to formulate their policy decisions by providing data on a different population. It would also enable the state to estimate the numbers of

patients with ED visits who are not enrolled in managed care organizations, and thus supplement the numbers provided to the ADWG by the eight managed care plans. If successful, DHS would also be able to expand the system to other ED's.

The second major purpose of the surveillance system was to characterize the demographics of those patients with emergency asthma visits. DHS wanted to see if the demographics showed that any demographic subgroups, in particular African-Americans and children, were visiting the ED for asthma more frequently than others (1,3-8). If so, they could use the information to further assess other potential predictors, and to plan appropriate interventions. The information would be useful for the Oregon Health Plan (OHP), who could inform clinicians of the patients who should be especially targeted for interventions or special teaching. The Oregon Asthma Program (OAP) could compare the demographics with its other ED data sources to look for commonalities and differences.

Potential Purposes of the Surveillance System

In the future, in addition to simply being able to compare the numerical and demographic data with the yearly data from BRFSS and NHAMCS, the Oregon Asthma Program might want to determine whether any seasonal trends existed. Correlation with known environmental risk factors, such as pollen loads, diesel exhaust levels, and upper respiratory infections (4-5,7,36-38) would then be possible.

Such information would also serve as a baseline for policy recommendations. For example, the stakeholders could utilize information gleaned about seasonal trends to recommend modification of patient asthma action plans. In higher risk seasons, they might recommend that patients check their peak flow more often, or they might recommend that primary care providers schedule more frequent follow up visits. If higher risk demographic subgroups were discovered, the ADWG could use that information to specifically target the types of patient information they create and disseminate. They might alter the educational level of the message, the language used, the type of media employed, or the type of graphics. Sharing the information with the DHS Division of Environmental and Occupational Epidemiology (EOE) would also provide a baseline for its own respective public health educational efforts and policy recommendations.

Moreover, the state and OHSU desire the ability to track ED treatment trends. ED clinician noncompliance with the NAEPP guidelines is widespread nationally (39-41). The information would provide a quantitative baseline for clinical quality control programs at OHSU and thus serve as a basis for their clinician education programs. After continuous quality improvement (CQI) measures were implemented, one could determine whether or not improvement had occurred, and if more education should be instituted.

The work group could also use information about treatment trends to ascertain whether any improvement had occurred in clinician guideline compliance. If not, in partnership with OHSU, they could intensify educational efforts or use different educational

methods. The ADWG could also use these data to recommend assessment activities on the sources of physician resistance to guideline use. The latter in turn would serve as a basis for creating a policy to address the sources of resistance (42).

Finally, DHS would want to disseminate the information on the demographics and the magnitude of the public health burden to the Oregon Asthma Program stakeholders to augment the knowledge obtained from the managed care plans. The data would serve to provide a foundation for use in planning both patient and clinician interventions.

Description of the Pilot Surveillance System

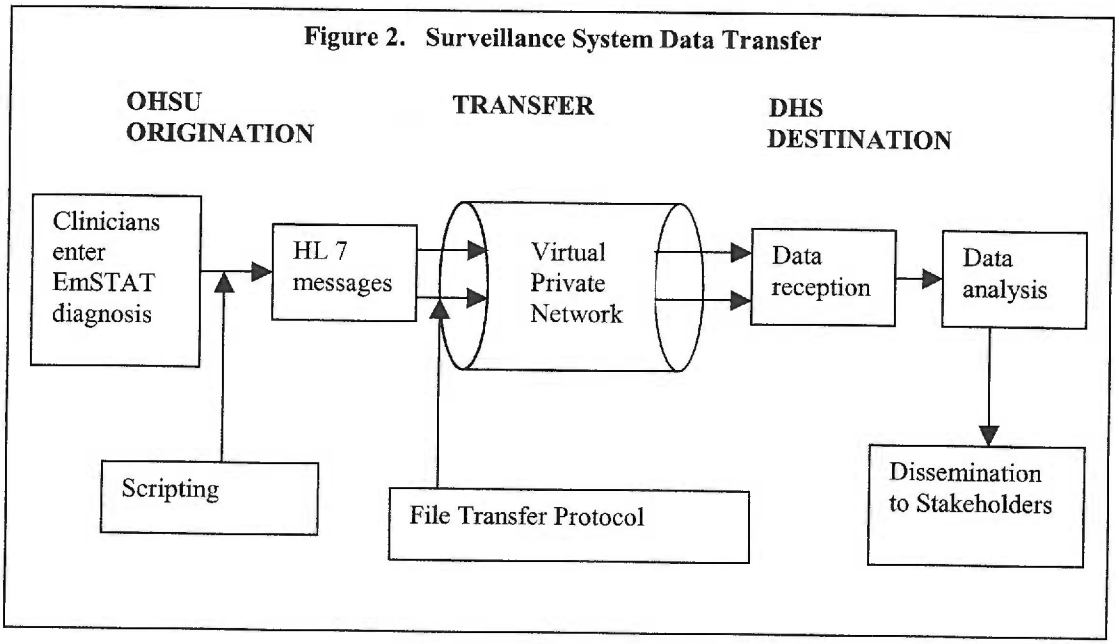
Setting: OHSU primarily serves the Portland tri-county metropolitan area. The ED patients are predominantly Caucasian (71.6%), female (52.7%), and the single most predominant payer (40.6%) is Medicaid. In 2001, OHSU had 35,223 ED visits; 974 asthma visits were due to patients aged 2-65, constituting 2.8% of OHSU ED visits (43).

Databases: At OHSU hospital, two databases are relevant to this system. Most ED encounter data are recorded on EmSTAT (A^4 Health Systems, Cary, NC), a computerized record containing pertinent clinical information. Included are the presenting complaint, current medications, vital signs, triage notes, nursing assessment, patient disposition, discharge instructions, and medications prescribed. Before patient discharge, clinicians must enter their diagnoses from a drop-down computer pick-list linked to ICD-9 CM codes. No free text entry is allowed.

In contrast, the Lifetime Clinical Record (LCR) comprises both electronic records and traditional paper charts. It contains free text data from all OHSU patients' hospital and outpatient encounters. It is far more comprehensive because it contains the original handwritten notes from all personnel involved in each encounter, as well as provider-dictated accounts. The LCR contains details of the medication record, past medical history, physical exam findings, laboratory values, radiology reports, and operative and procedure reports. Because of the comprehensive nature of this record, which is entirely separate from EmSTAT, it was used as the "gold standard" against which to determine the accuracy of the EmSTAT diagnoses.

Data flow: The surveillance system begins with an EmSTAT data entry by the ED clinicians just prior to patient disposition (Figure 2). The data then goes automatically through a process known as "scripting", which strips it of any personal identifiers, and translates it into a standardized Health Language 7 (HL7) format (44). It then passes through a "virtual private network" (VPN) which provides authentication and encryption. The VPN consists of two OHSU firewalls, a File Transfer Protocol (FTP), and A DHS firewall. Data passage through this transfer process currently occurs weekly, but originally occurred every four hours, and could easily revert to that schedule with only minor programming changes. The data messages pass to technicians with security clearance for access (45), and are subsequently available to a DHS epidemiologist for analysis and dissemination to the stakeholders in the Oregon Asthma Program.

Figure 2. Surveillance System Data Transfer



METHODS

I decided whether or not the system fulfilled the guidelines by evaluating the simplicity of the system set-up and operation, the ease of developing and validating the system's case definition, and the simplicity of collecting and analyzing the demographic data. For the flexibility criterion, I evaluated whether the system possessed a standard data format, whether it could easily accommodate changes in the case definition, and whether the granularity or detail level of the data elements was sufficiently fine to allow response to changing information needs. I examined the acceptability of the system with respect to federal standards for confidentiality, demographic descriptors suitable for federal research, and acceptability to the OHSU clinicians and to the state with regards to time demands and costs. The author also evaluated whether the system fit criteria for timeliness in initial set-up, and whether the data transmission rate was timely enough for annual analysis by DHS. I evaluated the data quality based on its degree of completeness, the degree of medical sophistication of the personnel responsible for entering the data, and whether the data collection form facilitated accuracy. I also evaluated the concordance of the LCR and EmSTAT demographic data. With respect to stability of the overall system, I investigated how often the system was not operational. I examined whether the OHSU ED asthma patients were representative of any larger populations with asthma, and whether the sample who met the case definition were representative of the larger population visiting the ED for asthma-compatible diagnoses. I determined the sensitivity and PPV of the system's surveillance diagnosis. I also determined the sensitivity of demographic subgroups for the potential utility in determining the PPV.

The data to perform the evaluation of the overall system were obtained via personal interviews with information technologists (IT) instrumental in system initiation and operation, and internal DHS documents. For evaluation of the system with regard to estimating the number of cases, I reviewed the EmSTAT and LCR patient records on the LCR and compared them, interviewed the IT personnel regarding procedures that would be necessary to change the surveillance diagnosis used by the system, and interviewed the DHS ADWG personnel regarding the system's acceptability and timeliness. With respect to the system's ability to characterize the demographics, I evaluated the captured data by characterizing the sample reported cases by demographic characteristics, and comparing those the data to the US 2000 Census, the CDC 2002 Asthma Surveillance Report, the 2000 NHAMCS Survey, the 2000 Oregon Vital Statistics, and Oregon 2000 BRFSS records.

I analyzed all numerical data using SPSS 10. To evaluate the balance between the sensitivity and specificity of the individual asthma diagnoses as compared to the aggregate surveillance diagnosis, I calculated receiver-operating characteristics for each individual diagnosis and for the aggregate. For evaluating whether the system's data could be used to detect significant differences in ED visits by month or season, I looked at the distribution of the data and analyzed it by the Pearson chi-square test of significance. To evaluate whether the system's data could be utilized to identify significant differences in whether patients received a steroid prescription or a follow-up visit appointment according to type of insurance, I used the patient insurance data

captured by the system and applied the Pearson chi-square test of the null hypothesis that insurance status was not significant. To evaluate the success of the overall system with respect to its intended purposes, I constructed a Likert scale and scored it according to each criterion subsumed under those purposes. I then summed the unweighted scores for each criterion to obtain a summary score.

EVALUATION OF THE OVERALL SURVEILLANCE SYSTEM

Implementation of the pilot system was somewhat problematic due to unforeseen DHS hiring freezes and the subsequent lack of the necessary personnel. At the time of this evaluation, no epidemiologist was available to perform the analysis. After arrival to DHS, the data were simply acquired and stored. An unbiased analysis of the system must consider its operation under both current circumstances and under optimal conditions. The guidelines of simplicity, flexibility, acceptability, timeliness, and stability are pertinent to this portion of the evaluation.

Simplicity

Methods: The CDC definition for simplicity refers to both system structure and ease of operation. A simple system is easy to set up and easy to use at the data collection site. It requires minimal data management, and no special training is required to collect and interpret the data (35). Therefore, I assessed the degree of complexity necessary for set-up and ease of operation according to the standards of highly experienced information technologists, J.A. Magnuson (DHS) and Christopher Bangs (OHSU). I assessed the degree of difficulty involved in training personnel at the data collection site by determining whether extra training would be necessary.

Results: The initial system setup was quite difficult even for experienced information technologists. Translation of EmSTAT messages into a standard messaging format, Health Language 7 (HL7), or "scripting", was initially quite complicated and required a high degree of skill in the use of Visual Basic (32). The initial programming of the HL 7 messages into a form suitable for passage through the "virtual private network" (VPN)

was extremely complex as well (32,46). Incompatibility between the two institutions' firewalls was difficult to resolve, and maintenance of an open VPN connection was difficult (32). However, once these steps were initially accomplished, the computerized aspects of the system ran automatically prior to adding asthma to the surveillance topics.

Once initiated, the surveillance system was extremely simple to use at the OHSU origination site. Providers in the ED continued to use EmSTAT in exactly the same manner as they did previously. No new training or additional procedure was required. The triage nurses selected a chief complaint category such as "respiratory" from a pick-list, and entered clinical data such as past medical history, medications, and allergies. The billing clerk then entered the demographic data. After the patient was assessed and treated, clinicians simply clicked on the appropriate diagnostic entry in the pick-list, as well as disposition.

Data analysis would be simple if an epidemiologist with standard biostatistical skills were available. No special training would be required. It would be straightforward to analyze the demographics or the long-term trends in the magnitude of the numbers of patients with ED asthma visits.

On the Likert scale presented at the end of the results section (Table 15), the simplicity criterion was given eight out of twelve possible points. Regarding the system's ability to meet objectives, no points were awarded for simplicity of set up, while the full four points each were awarded for simplicity of operation, and for the fact that no extra

training was needed for data analysis. Both of the latter criteria completely met the objectives.

Flexibility

Methods: CDC surveillance guidelines define a flexible system as one that has a standard data format that lends itself to easy data transfer, and can be adapted to dissimilar size institutions (35). I therefore ascertained whether the data would be easily transferable to other institutions, and whether those institutions could easily utilize the system for data collection and transfer.

Results: The system is only moderately flexible regarding the overall data transfer process. Larger institutions such as Kaiser Permanente and Providence have computerized ED systems dissimilar to EmSTAT. The differences would require a completely different initial scripting, authentication, and encryption process (32). The system therefore could not meet the CDC criteria for standard data formats that integrate easily into other systems. Additionally, the system requires a high degree of sophistication in terms of both financial and personnel resources, and in this respect is quite inflexible.

CDC guidelines also comment that this attribute is best evaluated retrospectively, in response to a new system demand. However, in the absence of this event, flexibility in present circumstances is equally important. In this type of surveillance system, one of the

important questions is whether the system is flexible enough to be adapted to bigger or smaller institutions. This is termed "scalability" by the information technologists (32,44).

A 2002 DHS survey of 58 Oregon hospital ED's revealed that the current system is not very scalable (46). First, 27% of the 41 respondent hospitals stated that any data exchange with outside agencies, such as DHS, was impossible. Of the 41 hospitals sampled, only 15 used the HL 7 text message format, while the remainder used a variety of formats such as MS Access, Excel, dBase, HTML/XML, Dataflex, and Oracle. When asked to express their degree of interest in developing a statewide information exchange network between ED's, 63% of the 41 hospitals surveyed were very interested but were unable to devote reasonable resources (46).

The Likert scale score (Table 15) for flexibility was two out of eight possible points. The criterion of flexibility of data collection/transfer scored one point because it could only slightly meet the objectives for the system. The level of scalability also earned one out of four points for the same reason.

Acceptability

Methods: CDC guidelines, while freely admitting that acceptability is a largely subjective attribute, state that the willingness of persons and organizations to participate in the surveillance system is the defining characteristic. Quantitative measures of acceptability include the subject or agency participation rate, and physician or facility

reporting rates (35). I investigated whether both key institutions necessary to the system participated, and OHSU physician reporting rates.

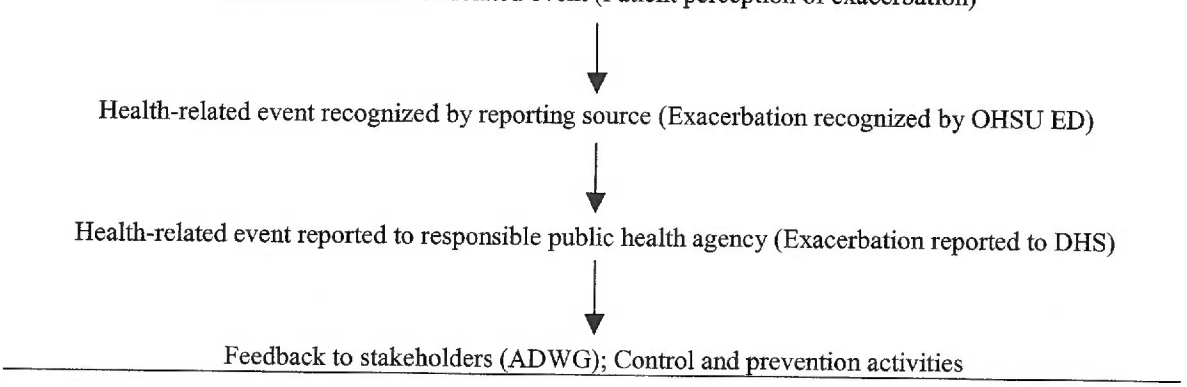
Results: The pilot system performed well at the origination site. It was highly acceptable to the OHSU clinicians, whose reporting rate was 100%. The system was convenient as it was immediately available at the workstations, and easy to use. No extra time was required to enter the relevant data, as procedures for EmSTAT use remain unchanged. However, I found the system was not equally acceptable to DHS, for reasons elaborated later.

The Likert scale score (Table 15) shows that acceptability as measured by agency participation earned no points, demonstrating its complete inability to meet the system objectives in that respect. However, it earned the full four points for OHSU clinician reporting rate, as it completely met system objectives. The total for this criterion was four out of eight possible points.

Timeliness

Methods: The CDC guidelines define this attribute as the speed between steps in the surveillance system but do not comment on the preceding step, setting it up. However, because this too is an important consideration, I determined the time necessary to initiate the system. Figure 3 shows the steps in an asthma surveillance system, modeled on the CDC schema (35).

Figure 3. Steps in an Asthma Surveillance System, Modeled on the Schema in the CDC Guidelines



Results: In this case, the project was not implemented in a timely fashion and ran over the projected timeline, finishing a year later than expected. Significant challenges that required resolution included application restrictions and incompatibilities, technical malfunctions, changing standards, insufficient dedicated resources, and coordinating project security with enterprise security (32).

Without additional data elements added to the system, it would not be possible to assess the duration between the patient's subjective experience of an asthma exacerbation and their diagnosis at OHSU. While this would constitute interesting data for other purposes, such as examination of access and enabling factors, it was not within the scope of this surveillance system.

Whether the current system is timely in other aspects depends on the intended use of the data, and is addressed in more detail later. However, a few summary comments may provide an overview of the issues. Batched data on the incidence of emergent asthma visits are transmitted to the state weekly. This rate is certainly sufficient to allow the

state to monitor the frequencies of emergent asthma visits. It would also be quite timely should the state epidemiologists ever attempt to correlate the counts of emergent asthma ED visits with influenza cases or environmental factors, such as particulate or diesel exhaust levels. Additionally, this rate of transmission is far in excess of what the stakeholders in the Oregon Asthma Program need. In order to implement its varying control and prevention activities, the ADWG states that monthly data would be sufficient (47).

However, in contrast to the system's theoretical timeliness, because of the lack of an epidemiologist to disseminate the data to the stakeholders, and the subsequent passive acquisition of stored data, the current system certainly cannot be deemed timely. For the same reason, lack of funding for an epidemiologist, timeliness is lacking in the system's ability to detect trends (32).

The Likert scale score (Table 15) for timeliness of initiation was 0 out of four possible points. It did not meet system objectives at all.

Stability

Methods: This characteristic involves the public health surveillance system's ability to remain reliable regarding data collection, management, and dissemination, and its ability to remain operational and available when needed (35). One CDC measure of system stability is the number of unscheduled outages and down times for the system's computers. Another is the presence of workforce shortages. I investigated how often the

system was not operational in terms of computer-related functions, and in terms of lack of dedicated personnel.

Results: OHSU server crashes have been problematic since the system's inception, and remain a source of some instability. However, such technical problems have become increasingly rare, and in general the system is quite stable. Only one server crash in the spring of 2001 affected the system (32,48). Currently, the major source of instability is in the area of data analysis and dissemination, and is secondary to lack of financing and consequent personnel changes within the state system.

The three stability criteria are each worth a possible four points on the Likert scale (Table 15). Computer-related stability and OHSU workforce stability each earned four points because they completely met the system objectives. DHS workforce stability earned none, because it did not meet the objectives at all. The total for stability was eight of twelve possible points.

Summary Likert Score for the Overall System

Eleven unweighted criteria were evaluated with respect to how the system met objectives. Each was worth a maximum of four points if it completely met the objectives, so that the total score possible for this section was 44 points. The system only earned 22 points (.50), indicating that much improvement is needed in this area.

EVALUATION OF THE SYSTEM'S ABILITY TO ESTIMATE THE NUMBER OF CASES

I evaluated the surveillance system's ability to estimate the number of cases with all of the guidelines except for stability and representativeness. Stability considerations are no different than for the overall system operation. A priori, the numbers of cases were not expected to be representative of the numbers of cases anywhere else.

Simplicity

Methods: The CDC guidelines mention that a simple surveillance system is one with a case definition that is easy to apply. To be useful for surveillance purposes, the case must be easily ascertained (35). Therefore, I examined the ease of using the case definition ultimately chosen. Additionally, I examined the degree of difficulty involved in choosing and validating the case definition.

Results: To estimate the numbers of OHSU ED asthma patients, the project team needed to choose a surveillance case definition. A standard definition provides certain advantages. It is necessary to improve the comparability of asthma surveillance data (49). Additionally, it would provide consistency in interstate comparisons and temporal analyses. Estimates derived could serve as benchmarks for evaluation of public health programmatic activity (50).

No universally accepted asthma definition exists (51-54), nor does any confirmed case classification outside of clinical and laboratory data (Table 3).

Table 3. Council of State & Territorial Epidemiologists Criteria For Confirmed Asthma, 1998

Clinical Criteria
Presence of wheezing lasting >2 consecutive days
Chronic cough that responds to bronchodilation that persists 3-6 weeks in the absence of allergic rhinitis or sinusitis
Nocturnal awakening with dyspnea, cough, and/or wheezing in the absence of other medical conditions known to cause these symptoms
Definitive Laboratory Criteria
Pulmonary function testing (spirometry: FEV1, FVC) demonstrating a 12% increment after the patient inhales a short-acting bronchodilator
A 20% decrement in FEV1 after a challenge by histamine, methacholine, exercise, or cold air
20% diurnal variation in peak expiratory flow over 1-2 weeks.

Obviously, such complexity is unsuitable for surveillance and for ED use. Therefore, I developed an asthma surveillance clinical case definition, and classification into probable and possible cases, modeled on the 1998 Council of State and Territorial Epidemiologists (CSTE) criteria. My case definition for confirmed asthma in both children and adults includes any of the criteria listed in Table 4.

Table 4. Surveillance Case Definition, Modeled on the 1998 Criteria from Council of State & Territorial Epidemiologists

Confirmed Case:
In the absence of supporting laboratory or clinical data, a history of taking/having taken asthma medications prescribed by a physician within the past year.
Hyperinflation on chest X-ray (CXR) in the absence of emphysema.
Wheezing during normal breathing, or prolonged expiratory phase, in the absence of cardiac problems.
Wheezing or chronic cough in the absence of a respiratory infection.
History of hospitalization for asthma-related problems.
Significant relief/improvement in objective measures of breathing capacity, such as increased breath sounds, and/or increased pulse oximetry (oxygen saturations), and/or increased peak flow, after bronchodilator therapy
Probable Case:
First known episode of wheezing or bronchospasm associated with a respiratory infection.

Exclusionary criteria differ for the adult and pediatric populations. The case exclusions for both are listed in Table 5.

Table 5. Exclusionary Criteria for Children and Adults, 1998 Council of State And Territorial Epidemiologists

Pediatric
1. Obstructions involving the large airways: foreign body in trachea or bronchus, vocal cord dysfunction, vascular rings or laryngeal webs, laryngotracheomalacia, tracheal stenosis, bronchostenosis, enlarged lymph nodes or tumor.
2. Obstructions involving the small airways: viral or obliterative bronchiolitis, cystic fibrosis, bronchopulmonary dysplasia.
3. Other causes: heart disease, recurrent cough not due to asthma, GE reflux, aspiration from swallowing mechanism dysfunction.
Adult
1. Chronic obstructive pulmonary disease (chronic bronchitis or emphysema), congestive heart failure (CHF), pulmonary embolism (PE), laryngeal dysfunction, mechanical airway obstruction (tumor), pulmonary infiltration with eosinophilia, cough secondary to drugs, vocal cord dysfunction.

After choosing the case definition, I validated some of the EmSTAT diagnoses being used for asthma visits through a labor-intensive process of chart review, using the clinical details described in the Lifetime Clinical Record (LCR) as the "gold standard". The project team had previously selected 13 EmSTAT diagnoses compatible with asthma. I obtained a list of all 2001 visits for patients aged 2-65 who were given one of these diagnoses. The candidate diagnoses are listed in Table 6. Three diagnoses were never used (asthma with allergic rhinitis, asthma with hayfever, and chronic obstructive airways disease). The fourth and eleventh diagnoses are redundant (asthma with status asthmaticus, and status asthmaticus) but are listed in this table because both were allowable pick-list diagnoses. They were later combined into one for data analysis. Patients given more than one diagnosis were assigned to the group with the smallest N.

Table 6. EmSTAT Candidate Diagnosis Totals for All Twelve Months of 2001.

EmSTAT diagnoses	Total Diagnosis Candidates N=974; includes patients with more than one diagnosis (% of total)	Sample Diagnosis Candidates N= 197[1]; includes patients with more than one diagnosis (% of total)	Sample Candidates N=40[2]; only those (20) patients with two diagnoses	Sample Candidates N=157[3]; patients with a single diagnosis (% of total)
1. Asthma, acute	345 (35.4%)	32 (16.2%)	12	20 (12.7%)
2. Asthma with allergic rhinitis	0	0	0	0
3. Asthma with hayfever	0	0	0	0
4. Asthma, status asthmaticus	4 (0.4%)	4 (2.0%)	0	4 (2.5%)
5. Bronchitis, acute with bronchospasm	53 (5.4%)	32 (16.2%)	4	28 (17.8%)
6. Bronchospasm	19 (2.0%)	13 (6.6%)	2	11 (7.0%)
7. Chronic obstructive airways disease	0	0	0	0
8. Dyspnea	95 (9.8%)	23 (11.7%)	2	21 (13.4%)
9. Reactive airways disease	230 (23.6%)	40 (20.3%)	6	34 (21.7%)
10. Shortness of breath	194 (19.9%)	24 (12.2%)	7	17 (10.8%)
11. Status asthmaticus	1 (0.1%)	1 (0.5%)	1	0
12. Viral URI with reactive airways	11 (1.1%)	9 (4.6%)	0	9 (5.7%)
13. Wheezing	22 (2.3%)	19 (9.6%)	6	13 (8.3%)

1. Numbers total 197 for the number of times the EmSTAT diagnoses were used, because 20 patients had more than one diagnosis; total percent is 99.9 due to rounding error.
2. Categories are not mutually exclusive, so numbers total 40 among the 20 patients.
3. Numbers total 157 patients without duplicate diagnoses; total percent is 99.9 due to rounding error.

Ultimately, DHS ended with a simple aggregate surveillance definition that included four EmSTAT diagnostic groups: asthma, acute; asthma, status asthmaticus/status asthmaticus; bronchospasm; and reactive airway disease. However, the results of my evaluation show that the process of choosing a case definition for asthma, and the process of evolving a surveillance definition, was far from simple.

On the Likert scale (Table 15) the criterion for simplicity of developing a case definition earned one point, reflecting that it only slightly met the system objectives. As choosing and validating the case definition was very difficult, that criterion earned no points. Only using the surveillance case definition earned the four possible points, as it completely met the system objective of ease of use. Total score was therefore five of twelve possible points.

Flexibility

Methods: It is reasonable to expect that as knowledge about asthma grows, some of the prior diagnoses included in the surveillance definition might be excluded for lack of specificity. Also, trends in nomenclature change with discovery of additional medical knowledge. Lastly, because OHSU is a teaching hospital, and the residents and attending physicians change frequently over the years, usage patterns of diagnoses could easily change as well.

I investigated whether the system possessed flexibility sufficient to accommodate changes in the case definition. If the system lacked the flexibility to accommodate such changes, DHS would lose the ability to get an accurate estimate of the numbers of patients visiting the ED for asthma exacerbations, and additionally would gain non-comparable data over time. No changes should have to be implemented within the system if the case definition standardizes or evolves over time. No new software, hardware, or resources should be necessary. Therefore, I investigated whether the system could easily adapt to changes in the aggregate surveillance diagnosis.

Results: It is conceivable that with changes in ED personnel over time, usage of particular EmSTAT labels on the pick-list might also change. For example, one particular attending physician might always choose "wheezing" as their preferred diagnosis. The system is flexible enough so that the other diagnosis, if validated, could easily be added back as one of those under surveillance. Conversely, it would be easy to remove diagnoses. The process would take approximately one hour of information technologist time to change the pertinent programming (45).

The Likert scale score (Table 15) for this item was four out of four possible points. It completely met the system objectives for flexibility in changing the case definition.

Data quality

Methods: The CDC guidelines indicate that one indirect indicator of validity is the quality of training and supervision of persons who complete these surveillance forms

(35). The "gold standard" for determining whether these visits truly are asthma cases would be diagnoses from pulmonologists or allergists/immunologists. However, this level of accuracy is not practical nor is it needed for a population-based asthma surveillance system, which seeks to know the numbers of cases, and does not need the level of accuracy required for a case-control study, for example. Nor is the validity as crucial as would be needed if ED personnel were participating in a bioterrorist/syndromic surveillance system. The latter situation would require virtual 100% sensitivity, especially because there may be only a few cases at first. Because those might represent only a small fraction of the numbers truly affected, it would be critical to detect all of them. Because asthma is a common chronic disease, the diagnoses made by the residents, attendings, and nurse practitioners in a fully accredited hospital must be assumed to be as clinically valid as those made elsewhere, and sufficient for the purposes of population surveillance. Therefore, I investigated what type of ED personnel were instrumental in entering the final diagnoses, which serve as the basis for the estimating the numbers of cases.

Another validity issue pertains to whether data are entered accurately, once the diagnosis is made. The CDC guidelines include "clarity of electronic surveillance forms" as one factor influencing data quality. A visually unambiguous electronic form, one that is easy to use for all ED personnel, facilitates accurate data entry and decreases the probability of random misclassification. Additionally, data accuracy improves when unambiguous choices are available simply by clicking on the appropriate diagnosis. In free text formats, such as the traditional paper chart, clinicians often write illegible diagnoses, or

ambiguous diagnoses that reflect their diagnostic uncertainties. An automated format such as EmSTAT precludes this difficulty. Therefore, I investigated the clarity of the form that the ED clinicians had to use.

Results: I determined that only the ED clinicians were responsible for selecting the final EmSTAT diagnosis, not the triage nurses nor the billing clerks. The clarity of the EmSTAT electronic form is easily seen. An example of the EmSTAT form is included in Appendix A. A form that is difficult to use would increase the numbers of non-respondents, particularly in a setting with busy clinicians attending to emergently ill patients.

The Likert scale (Table 15) score for data quality was eight points out of the eight possible for this section. The quality of training of those entering the diagnosis received four points for completely meeting the system objectives. The same score applied to the clarity of the data entry form regarding its influence on data accuracy.

Timeliness

Methods: As previously mentioned, the CDC guidelines define this attribute as the speed between steps in the surveillance system (Figure 5). This discussion will not include the first step. Examination of the time interval between patient perception of severe dyspnea and treatment at the ED, although a topic of significant interest in the asthma literature (55-59), was not one of the original purposes of this surveillance system. This system was simply intended to be timely enough for the state to track yearly trends in

frequencies of emergent asthma cases. This would allow comparison with the statistics obtained from BRFSS and from the ADWG data from managed care. Therefore, I investigated whether the data transmission rate was sufficient for this purpose.

Results: I confirmed with the DHS information technology staff that transmission of batched data on emergency asthma visits occurs weekly (48). Because DHS would only compare these data with those from BRFSS or ADWG on a yearly basis, a weekly rate is more than sufficient.

In theory, it would also be quite timely should the state epidemiologists ever attempt to correlate the rate of emergent asthma ED visits with influenza rates or environmental factors, such as particulate or diesel exhaust levels. Additionally, this rate of transmission is actually far in excess of what the stakeholders in the Oregon Asthma Program need. In order to implement its varying control and prevention activities, program staff members say that monthly data would be sufficient (47).

Although not conceptualized as an original purpose for the system, ideally, it should also be timely enough to track unusual spikes in the estimates of asthma cases. Potentially, such an acute rise in numbers could be the first indication of a new problem or risk factor, such as a new virus, or a daily increase in pollution levels. An appropriate time frame for this purpose would be daily transmission, and this could easily be accomplished with only minor programming changes.

The system completely met the timeliness criterion for this purpose because it provides data at a rate sufficient for the uses of the state. Therefore, on the Likert scale (Table 15) it received four out of four possible points.

Acceptability

Methods: CDC guidelines state that some qualitative issues are the public health importance of the health-related event under surveillance, whether the time demands of the system are acceptable to personnel, whether the costs are acceptable to the participating agencies, and whether the system met requirements for confidentiality (35). I ascertained whether the public health importance of the health-related event was highly valued by all the participants in the system, and whether that degree of importance was felt to justify the costs and the burden on time relative to available time. I investigated whether the system met national standards for confidentiality of patient data for each participant.

Results: The use of encryption and other security measures ensure confidentiality, so that the data recipients cannot identify any of the individual patients who constitute the emergent asthma cases. This constitutes an important issue, as asthma is not a reportable disease. Because patients do not realize that their data are being transmitted, and thus do not give permission, confidential transmission constitutes the only ethically permissible mode. The system is acceptable in terms of HIPAA criteria to the hospital system.

All of the stakeholders within DHS agree on the public health importance of data on emergent asthma visits. The state needs additional data sources beyond those from managed care plans, and data collected directly from ED's is certainly desirable to augment prior knowledge. The ADWG is keenly interested in acquiring data that might further outline factors influencing emergent asthma visits, including NAEPP-noncompliant ED discharge behaviors (47).

However, the system must be deemed unacceptable in financial terms, as defined by the failure of the CDC to continue funding the system. Although the cost of OHSU data collection is negligible because of its completely automated nature, the remainder of the cost is unacceptable. Security costs exceeded initial estimates, and the human resources available to the project were restricted by workload constraints (32). The initial cost to add asthma surveillance to the existing reporting infrastructure was $138,224. The exact breakdown is not available to the author. However, for continuing system operation, projected personnel costs listed in budget documents included 1.0 FTE for an epidemiologist 2, .05 FTE for a consulting ED physician, .10 FTE for an EmSTAT database manager, and unspecified amounts for administrative support and the supervising medical epidemiologist. Continuation costs for 2001-2002 were $43,748 and approximately another $42,000 was projected for 2002-2003, had the project continued (60). Funding a DHS epidemiologist to analyze these numbers, without CDC financial support, is not possible in the current financial climate.

The Likert score (Table 15) for acceptability of the system was eight out of twelve possible points. All participants agreed on the public health importance of the problem, and the system met confidentiality requirements in an acceptable manner. These two criteria therefore earned four points each for completely meeting the system objectives. However, the cost to DHS was deemed completely unacceptable, and thus did not meet the system objectives, earning no points.

Sensitivity

Methods: CDC guidelines state that, at the level of case reporting, sensitivity refers to the proportion of cases detected by the surveillance system (35). Because it is not possible to determine the numbers of asthma patients given other EmSTAT diagnoses, such as "cough" or "malaise", it is not possible to obtain the absolute sensitivity of the system. Instead, for the reference "population", I used the random sample of OHSU asthma ED patients aged 2-65 who did meet our case definition. The project team had previously eliminated the age extremes because of the high prevalence of exclusionary criteria and serious comorbidities.

In any surveillance system, a tradeoff must be made between sensitivity and specificity (61). No "gold standard" for adequate system sensitivity exists. In a surveillance system designed to detect an acute disease with rapid symptom progression and a high case-fatality rate, sensitivity should be virtually 100%. However, since asthma is a chronic disease with acute exacerbations, I did not need the same degree of certitude. I needed to be able to balance a fairly good sensitivity with a fairly good specificity as well, and felt

that aiming at 70% sensitivity might provide this balance. I wanted most of the ED patients who truly had an emergent asthma episode to have one of the diagnoses in our surveillance system. Therefore, I determined the ability of the pilot system to correctly identify emergent asthma cases at least 70% of the time.

Results: Of those 177 sampled patients visiting the ED with the four selected diagnoses, after the LCR chart review 92/177 (51.9%) met the case definition. Twenty patients of the 92 did meet the clinical criteria for asthma, but did not have one of the EmSTAT diagnoses ultimately selected for surveillance (11.3%). Of the 177, ninety patients (50.8%) had the EmSTAT diagnoses chosen for surveillance (Table 7).

Table 7. Comparison of Concurrence of Asthma Patients as Defined by Chart Audit Versus EmSTAT Aggregate Surveillance Diagnosis

	Met case definition			
EmSTAT surveillance diagnosis	**+**	**-**	**Totals**	
+	72	18	90	PPV[1]=80%
-	20	67	87	
Totals	92	85	177	
	SN[2]= 78.3%	SP[3]=78.8%		

1. PPV= Positive Predictive Value
2. SN= Sensitivity
3. SP= Specificity

Sensitivities of the individual candidate EmSTAT diagnoses, as compared to the remaining EmSTAT asthma diagnoses, are shown in Table 8. None individually came close to 70% sensitivity. For example, if the system had used "acute asthma" as its only surveillance diagnosis, the sensitivity would be only .30. By aggregating four of the diagnoses with the highest PPV (asthma, acute (.87); asthma, status asthmaticus (.60); bronchospasm (.69); reactive airways disease (.80)) I was able to improve the sensitivity to 78.3% (Table 7). These results are based on whether the individual picked up by the system has at least one of the EmSTAT surveillance diagnoses, as occurred in 11.3%

(20/177) of our sample (Table 7). It is possible that the sensitivity might decrease if patients with duplicate diagnoses were eliminated.

Table 8. Distribution of Sensitivity, Specificity, and Positive Predictive Value for the Individual EmSTAT Diagnosis Candidates for the Surveillance System, as Compared to the Remainder of those Diagnoses.

EmSTAT diagnoses[1]	N=974	Sample N=197[2]	Met case definition	PPV	Sensitivity	Specificity
Asthma, acute	349	32	28	.87	.30	.95
Asthma, status asthmaticus/status asthmaticus	5	5	3	.60	.03	.98
Bronchitis, acute with bronchospasm	53	32	9	.28	.10	.73
Bronchospasm	19	13	9	.69	.10	.95
Dyspnea	95	23	7	.30	.08	.81
Reactive airways disease	230	40	32	.80	.35	.91
Shortness of breath	194	24	6	.25	.07	.79
Viral URI with reactive airways	11	9	3	.33	.03	.93
Wheezing	22	19	11	.58	.12	.91

1. The nine remaining EmSTAT diagnoses after eliminating redundancy or those not used.
2. The 177 patients randomly selected from the 974. Numbers total 197 for the number of times the EmSTAT diagnoses were used, because 20 patients had duplicate diagnoses.

Interestingly, calculation of the ROC for the aggregate surveillance system confirms that I found an appropriate empiric balance for the sensitivity and specificity (Table 9). Creating an aggregate diagnosis not only improved the sensitivity, but also the area under the curve (AUC).

Table 9. Receiver-operating Characteristics for the Individual EmSTAT Diagnoses

Diagnosis	AUC*	.95 CI	SE	Asymptotic Significance
Asthma, acute	.687	.600, .775	.045	.001
Asthma, status asthmaticus	.457	.205, .708	.128	.767
Bronchitis, acute	.630	.413, .847	.111	.243
Bronchitis, acute with bronchospasm	.352	.250, .454	.052	.009
Bronchospasm	.631	.465, .797	.085	.085
Dyspnea	.418	.280, .557	.071	.207
Reactive airways disease	.664	.575, .753	.045	.002
Shortness of breath	.350	.234, .466	.059	.018
Status asthmaticus	.938	.858,1.017	.040	.132
Viral URI with reactive airways	.494	.407, .581	.045	.892
Wheezing	.506	.379, .634	.065	.928
Aggregate surveillance diagnoses	.760	.688, .832	.037	<.001

*Area under the curve

This criterion earned the full four points on the Likert scale (Table 15). It completely met the system objective for a sensitivity of at least 70% for detecting cases.

Positive Predictive Value

Methods: According to the CDC guidelines, in assessing the PPV, primary emphasis should be placed on the confirmation of cases reported through the surveillance system. At the level of case detection, the PPV affects the amount of resources used for case investigations (35). In this case, the relevant resources would be the ADWG personnel and time needed to track these visits, and to perform the comparisons with the ED data from managed care plans.

In the pilot, the surveillance system was intended to be able to correctly predict that the aggregate surveillance diagnosis could predict at least 70% of the emergent asthma cases. Asthma already has an alarmingly high prevalence, and is expected to continue becoming

increasingly prevalent. I used results from the chart review as the gold standard, and compared the EmSTAT diagnoses against them to get PPV's for the individual diagnoses. I then reviewed the PPV of the aggregate diagnosis chosen for the surveillance system.

Results: Positive predictive values for the individual EmSTAT diagnoses, shown in Table 7, ranged from 0.25 (shortness of breath) to 0.87 (acute asthma). Using a cut-off of .60 for PPV, the four diagnoses chosen for surveillance included: asthma, acute; asthma, status asthmaticus/ status asthmaticus; bronchospasm; and reactive airway disease. By restricting the number of diagnoses used for surveillance, positive predictive value for the system (Table 6) improved to 80.0% (72/90), and thus exceeded the criteria for the pilot. If all candidate diagnoses had been used, the averaged PPV would be only 56%.

The Likert scale score (Table 15) for this criterion was four points out of a possible four. The system completely met the objective for a positive predictive value of at least 70%.

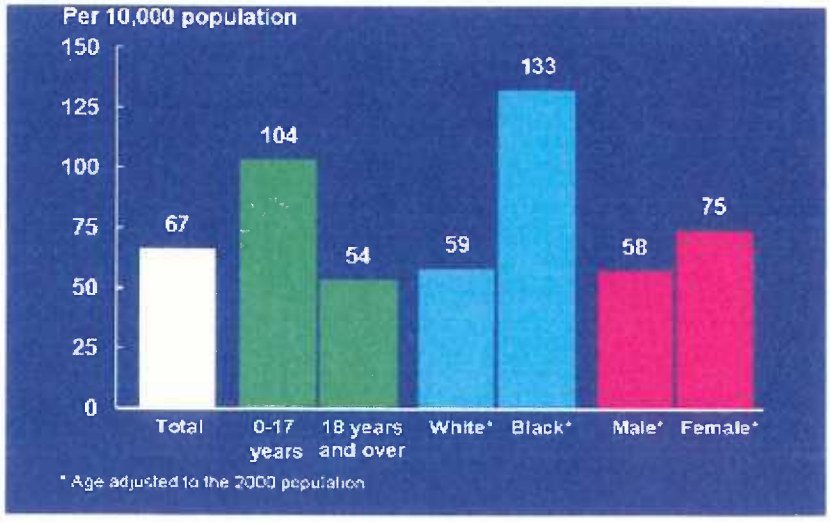
Summary Likert Score for Estimating the Numbers of Cases

Twelve unweighted criteria were used to evaluate whether the system met the overall objectives for estimating the numbers of asthma ED cases at OHSU. Because each is worth a maximum of four points, the total possible score is 48 points. The system earned 37 points (Table 15), thus earning a score of .77 in this section.

EVALUATION OF THE SYSTEM'S ABILITY TO CHARACTERIZE PATIENT DEMOGRAPHICS

In addition to correctly estimating the numbers of patients with emergency asthma visits, a goal of the system was to characterize the local demographics. National studies have tended to show that blacks and young children are disproportionately represented among those with ED visits for poorly controlled asthma (1,3,4,6,8). In part, this simply reflects that, overall, a higher ED utilization rate exists for African-Americans. By 1999, the asthma ED visit rate for African-Americans (174.3/10,000) was almost three times the rate for whites (59.4/10,000), and was also more than twice the national rate for asthma ED visits (73.3/10,000) (3,6). In 2000, the overall ED utilization rate for black persons was 62% higher than for white persons (18). By 2000, the crude rates of ED asthma visits for blacks (142/10,000) had climbed to nearly two and a half times that for whites (58/10,000) (6,11,18). African-Americans visited the ED for asthma about 125% more than whites (Figure 4)

Figure 4. Demographic Characteristics of US Asthma Patients with ED Visits 2000 – National Center for Health Statistics (N=1.8 million)



I wanted to see if our demographics showed the same disproportionate representation. I also wanted to determine whether some demographic subgroups had an increased incidence for these visits. If so, the information could be used to further assess other potential predictors, and to plan appropriate interventions.

I used all of the CDC guidelines in this section, with the exception of stability and timeliness. As mentioned in the previous section, stability considerations are no different than for the overall system operation. Timeliness considerations are identical to those in the section evaluating the system's ability to estimate cases.

Simplicity

Methods: CDC guidelines focus on the method of obtaining the demographic data, whether any special staff training requirements exist, the methods for analyzing the data, and the level of integration with other systems (35). Therefore, I ascertained how the demographic data were collected, how simple it would be to analyze the data compared with that from other state and national sources, and whether the EmSTAT system was fully integrated with other internal OHSU databases.

Results: The mechanics of obtaining demographic data on age, sex, race/ethnicity and county of residence are similar. All data are obtained by self-report, and easily entered by the ED registration clerk into the automated EmSTAT record. These data are sent bundled and, theoretically, would be easy for a DHS epidemiologist to analyze with

regard to age and sex. However, comparison of the OHSU surveillance system data with other state or national data is not simple.

This problem is not unique to either OHSU or DHS data. Lack of consistency in classification is a major problem in the public health field (62-66). Table 10 shows the lack of consistency in the racial/ethnic and insurance classifications used in various analyses. For example, OHSU hospital data use the characterization "Asian/PI", while the Oregon BRFSS uses "Asian" and ascribes "PI" to another category. Additionally, it only gives demographics in terms of the percent of the respondents, not of the population. Healthy People 2010 uses "Asian/PI" and "Native Hawaiian and other PI". The ED asthma statistics designate a general "Medicaid" designation without reference to type, while the designation "Private" was not expanded to include managed care. Additionally, most of the databases used to derive these figures are not linked, precluding any sort of easy analysis (62,67-68).

Table 10: Demographic Characteristics as a Percent of the Sample Population

	Oregon BRFSS 2001	Multnomah County 2000[1]	OHSU Hospital 2001[2]	OHSU ED Cases 2001	OHSU ED Asthma Cases 2001
Race/Ethnicity					
Asian/PI	1.6[3]	5.7	3.5	3.2	5.7
African American	1.0	5.7	3.2	7.9	8.7
Native American/AK	2.0	1.0	0.5	.01	1.1
Caucasian	91.1	79.2	83.9	71.6	76.1
Other	3.7	4.0	2.2	2.4	0
Hispanic	NS[4]	7.5	6.8	14.1	8.7
Native Hawaiian/ PI	0.5	0.4	NS	NS	0
Insurance					
Private	NS	NS	NS	NS	25.0[5]
Commercial	NS	NS	7.1	8.2	NS
Managed Care	NS	NS	26.4	20.3	NS
MEDICAID					53.3[6]
Medicaid OR	10.4	NS	37.8	39.8	NS
Medicaid Other	NS	NS	1.4	0.8	NS
Medicare	NS	NS	12.1	8.5	7.6
Nonsponsored	13.9		13.7	21.6	12.0
Other sponsored	NS	NS	1.5	0.8	NS
Unknown	NS	NS	0	0	8.7
Sex					
Male	NS	49.5	46.5	47.3	45.6
Female	NS	50.5	53.5	52.7	54.5
Age					
<18	**NS**	**22.3**	**27.0**	**48.2**	**29.3**
Age groups					
2-18	NS		20.3	29.3	29.3
>18		**77.7**	**73.0**	**51.8**	**70.7**
Age Groups					
19-30	NS	NS	NS	NS	22.8
31-40	NS	NS	NS	NS	17.4
41-50	NS	NS	NS	NS	18.5
51-65	NS	NS	NS	NS	12.0
TOTALS	6305[7]	660,486	63,514	35,223	92

1 US Census Bureau
2 Exclusive of day & clinic patients; includes only inpatient, observation, ED
3 Without Pacific Islander
4 Not specified/not available
5 LCR records did not differentiate type of private insurance
6 LCR records did not differentiate type of Medicaid
7 Oregon Behavioral Risk Factor Surveillance System

The same problem occurs with age comparisons. The age data as presented in Table 10 are organized in a fashion that was most convenient to the project at one time. It could easily be organized in another fashion. However, although this would be easy to accomplish, and while it is simple to analyze the data within the system, it is difficult to compare the data to what is generally available. Various reports are organized with highly variable age categories. For ED asthma visits, Healthy People 2010 uses three age groups: under 5, 5-64, and over 65. The respondents to the Oregon 2001 BRFSS question "Do you still have asthma?" are all over 18. Therefore, it is difficult to compare these numbers in a meaningful fashion. However, this is not a fault attributable to this system, but rather to the lack of uniformity in data standards nationally. If these were standardized, the comparisons would be more easily performed.

The data in Table 9 confirm that African-Americans are seen at OHSU for asthma (8.7%) at levels disproportionate to their presence in Multnomah County (5.7%) and Oregon (1.0%). However, whether this is due to an increased disease rate, greater asthma severity, or to disproportionate use of OHSU as a safety net, is not known. One would need to obtain utilization data from other institutions to begin disentangling this issue.

The system is simple to use for analysis of age data. The system program automatically converts birth dates into years and months of age. The OHSU results do not confirm a preponderance of children visiting the ED for asthma. Unlike many other studies, very young children do not predominate within the total sample, those who met the case definition, or those with the diagnoses chosen for surveillance.

Another profound difficulty with this surveillance system originates because OHSU has internal "silo" databases lacking integration with each other. The only existing linkage between the EmSTAT database and the LCR database occurs for patients with previous hospital visits. An automated process using an HL7 message "backfills" demographic data on those patients (69). Integrating any other information from LCR takes manual chart review.

The possible Likert scale score (Table 15) for the four criteria used to evaluate this guideline is sixteen points. Two of these criteria, simplicity of data collection and simplicity of analysis within the system, received the full four points each because of their ability to meet the system objectives. However, because it was extremely difficult to integrate the data with other systems, the score was zero for this criterion. Because minimal comparative analysis was possible, the system only met objectives slightly in this respect and earned only one point. The system earned nine points for simplicity with respect to the objective of characterizing patient demographics.

Flexibility

Methods: One criterion for flexibility is the use of a standard data format for electronic interchange. As mentioned in the previous section, this surveillance system does not fulfill this standard. However, this is not the only measure of flexibility. The capacity to respond to changing information needs is another important consideration (35). For example, if an epidemiologist would desire the ability to pinpoint exact geographic

locations of patients suffering from asthma exacerbations, the system would need to be able to provide this level of detail. Therefore, I examined the detail level, or, as labeled by the information technologists, the "granularity" level of data elements in this system to ascertain whether this would be possible.

Results: The demographic data entered into the system include the exact street address, not just the county of residence. This is the highest available granularity, and is thus suitable for several purposes. If funds permitted, an epidemiologist might well decide to use GIS methods to help assess correlations of asthma exacerbations with particular locations. The data could then be used to explore further correlations with known environmental risk conditions, such as proximity to diesel truck routes, or substandard housing infested with cockroaches.

The Likert scale score (Table 15) for this section was the full four points out of four. The flexibility of the data completely met the system objectives for all present uses of the system.

Data Quality

Methods: CDC guidelines include data completeness and validity as necessary criteria to assess quality (35). Pertinent demographic characteristics should be available for the vast majority of patients, in order to provide information adequate for planning and policy efforts. A criterion of 95% completeness would provide a stringent but realistic goal.

Therefore, I ascertained the degree of completeness of data entry on the pertinent demographic variables.

Assessing validity of the racial/ethnic data provided is troublesome in several respects. First, and most fundamentally, the construct of race is an artificial concept (65, 70-72). Even ethnicity is a complex multidimensional construct, and how it is determined may easily bias or confound results (67, 73-75). Although federal standards exist, and their use would improve comparability, they limit options for defining and including some ethnic groups, while forcing inappropriate aggregation of other groups into single race categories (62,66).

Thus far, no studies on asthma have found racial/ethnic correlations indicating that increased exacerbations in certain groups have any biologic basis. However, racial/ethnic concepts still have much utility, as they are often markers for socioeconomic status and health disparities. Although social categorizations may be empirically derived, they are still important determinants of health status and offer useful criteria for targeting and evaluating intervention efforts (8,65).

The US Census Bureau and Oregon BRFSS rely on self-report for racial/ethnic identification. Therefore, self-report will be used as the "gold standard" for validity, and has the advantage that the same classification will be used for both numerator and denominator. I ascertained how the EmSTAT system assigned a racial/ethnic category, and compared it to the national standard of self-report.

I was also curious as to the degree of consistency between the demographic group assigned by EmSTAT, and that assigned by the treating clinician. The EmSTAT demographic assignment recorded by the registration clerk is obtained by self-report. The clinician assignment is based on visual impression. If a notable discrepancy had existed between the two, for example over 5%, the validity of the system for assigning a racial/ethnic category could come into question. Components of the surveillance system might need improvement. For example, it might indicate a problem with the data entry screen used by the registration clerks. I therefore examined the degree of concordance between the racial/ethnic category assigned by the clinician and the one on the EmSTAT registration screen.

Results: Table 11 below shows that data entry was 100% complete for all demographic variables except for county of residence. Two patients of the 177 (1.1%) did not live in Oregon, and the county of residence was not recorded either in EmSTAT or the LCR. This does not seem indicative of any particular problem with the surveillance system. Most likely, in an emergency situation, that particular detail was not deemed important enough to pursue.

Table 11. Completeness (%) of Demographic Data Entry in the EmSTAT System.

Characteristic	Available on EmSTAT	Degree of completeness (%)
Sex	Yes	100
Race	Yes	100
Age category	Yes	100
Insurance		
Medicaid	Yes	100
Medicare	Yes	100
Private	Yes	100
Self-pay	Yes	100
Unknown	Yes	100
County of Residence	Yes	99

The EmSTAT system relies on self-report for demographic data. Table 12 shows almost complete concordance between the race/ethnicity within the EmSTAT and LCR systems. The one mismatch occurred when the EmSTAT ethnic assignment was "Hispanic", while the LCR recorded "Iranian".

Table 12. Concordance Between EmSTAT & LCR* Racial/Ethnic Categories

Racial/ethnic Category Matches	Number	Proportion
Yes	91/92	.99
No	1/92	.01

*Lifetime Clinical Record

The Likert scale score (Table 15) for data quality was twelve out of a possible twelve points. The three criteria of completeness, concordance, and validity with respect to federal standards all met the system objectives completely, thus earning four points each.

Acceptability

Methods: The previously discussed considerations do not differ when the system's purpose is to obtain demographic data. However, an additional issue warrants attention. Although racial/ethnic data lack high specificity and strict disease correlates, they still have value as markers of socioeconomic status and its effect on health. One of the major foci of public health is to address national health disparities. Therefore, in order to be acceptable to other state and federal researchers addressing disparities, the descriptors of race/ethnicity in any asthma surveillance project should be commensurate with those accepted as suitable for federal research. I investigated whether the descriptors used in this surveillance system were consistent with this purpose.

Results: the descriptors provided by the surveillance system required self-assignment to one race and one ethnic group. This is consistent with federal standards (67). Additionally, the Council for Racial Equality has advocated that voluntary self-classified ethnicity is acceptable (63). Perhaps this will allay some minority fears that such data will be misused or will foster stigmatization and stereotyping (65).

The discussion on validity has already pointed out that racial/ethnic data are theoretically unacceptable to many researchers. Many feel that the concept of "place" is far more valuable in public health research (71-73).

The Likert score (Table 15) for acceptability was the full four out of four points. The descriptors were consistent with federal standards and thus the system met the relevant objective completely.

Sensitivity & Positive Predictive Value

Method: At this time, no method exists by which researchers could discover the sensitivity of the system for accuracy of the demographic data. However, one might be curious as to whether any of the individual demographic characteristics had higher sensitivities than others. If this were true, as the prevalence of asthma rose, the PPV for those characteristics would rise as well. I therefore determined the sensitivity and PPV of the individual demographic characteristics. Because I had previously found excellent concurrence between the EmSTAT demographic assignment and that from the LCR, I performed the analysis using the EmSTAT data.

Results: Table 13 shows the individual sensitivities and PPV's for the EmSTAT demographic characteristics. The white race demographic had the highest sensitivity for an emergent asthma visit. However, this finding is academic at this time; as previously mentioned, in this instance, the sensitivities are only relevant in the context of the PPV. The PPV for meeting the case definition for the entire sample is .52 (92/177); only the age category 2-18 is much more predictive of an ED asthma visit than would be expected by chance.

Table 13. Demographic Characteristic Sensitivities and PPV'S for Patients Who Met the Case Definition for Asthma (N=92)

Characteristic		Sensitivity	PPV
Sex			
	Male	.46	.53
	Female	.54	.52
Race/ethnicity			
	Hispanic	.09	.57
	White	.76	.53
	African-American	.09	.42
	Asian/PI	.05	.55
	Other	.01	.33
Insurance			
	Medicaid	.53	.51
	Medicare	.08	.37
	Private	.25	.62
	Self-pay	.12	.42
	Unknown	.09	.57
Age category			
	2-18	.29	.75
	19-30	.23	.53
	31-40	.17	.50
	41-50	.18	.52
	51-65	.12	.30

The Likert scale score (Table 15) for this item was the full four points out of four. The system was able to identify the sensitivity of demographic subgroups and thus met the system objectives completely.

Representativeness

Methods: A representative public health surveillance system is able to depict accurately the population distribution by place and person. Ideally, one would compare the demographic characteristics of the patients detected by the surveillance system to the larger population of patients visiting the ED for asthma emergencies. However, this is not feasible without a much larger study. The latter would also require validation procedures to determine that patients with diagnoses such as "cardiac asthma" were not included. Additionally, no reason exists to expect OHSU ED asthma patients to reflect the demographics of the county, its other ED patients, or the state. Referring back to Table 9 makes the lack of representativeness quite clear.

Therefore, I compared the demographics of those patients who ultimately met our case definition with the total sample, and with patients who had one of the surveillance diagnoses, whether or not they met the case definition. Strictly by chance, it would have been possible to have very dissimilar populations.

Results: Table 14 shows that the subset of patients who met the case definition was representative of the larger sample, and of those who carried the surveillance diagnoses.

Table 14. Comparison of Patient Demographic Characteristics Between the Total Sample, Those Who Met the Case Definition, and Those With the Final Surveillance Diagnoses Chosen*

Characteristic		Total Population N = 177	Met Case Definition N=92	Chosen for Surveillance N=90
Gender	Male	80 (45.2%)	42 (45.6%)	40 (44.4%)
	Female	97 (54.8%)	50 (54.4%)	50 (55.6%)
Race/Ethnicity				
	African American	19 (10.7%)	8 (8.7%)	10 (11.1%)
	Asian/PI	9 (5.1%)	5 (5.7%)	5 (5.6%)
	Hispanic White	14 (7.9%)	8 (8.7%)	8 (8.9%)
	Non-Hispanic White	132 (74.6%)	70 (76.1%)	65 (72.2%)
	Native American/Alaskan & other	3 (1.7%)	1 (1.1%)	2 (2.2%)
Insurance				
	Medicaid	96 (54.2%)	49 (53.3%)	50 (55.6%)
	Medicare	19 (10.7%)	7 (7.6%)	3 (3.3%)
	Self-pay	26 (14.7%)	11 (12.0%)	12 (13.3%)
	Private	39 (20.9%)	23 (25.0%)	18 (20.0%)
	Unknown	13 (7.9%)	8 (8.7%)	7 (7.8%)
County of Residence				
	Multnomah	120 (67.8%)	58 (63.0%)	60 (66.7%)
	Washington	23 (13.0%)	16 (17.4%)	16 (17.8%)
	Clackamas	12 (6.8%)	7 (7.6%)	7 (7.8%)
	Other (Oregon)	20 (11.3%)	10 (10.9%)	10 11.1%)
	Unknown (out of state)	2 (1.1%)	1 (1.1%)	1 (1.1%)
Age groups				
	2-18	36 (20.3%)	27 (29.3%)	28 (31.1%)
	19-30	39 (22.0%)	21 (22.8%)	19 (21.1%)
	31-40	32 (18.1%)	16 (17.4%)	11 (12.2%)
	41-50	33 (20.9%)	17 (18.5%)	17 (18.9%)
	51-65	37 (20.9%)	11 (12.0%)	15 (16.6%)
Smoking Status				
	Current smoker	59 (33.3%)	24 (26.1%)	24 (26.7%)
	Never smoker	10 (5.6%)	7 (7.6 %)	12 (13.3%)
	Past smoker	13 (7.3%)	3 (3.3%)	6 (6.7%)
	Passive smoker	9 (5.1%)	5 (5.4%)	8 (8.9%)

*See table 7 for crosstabulation of the cases meeting the audit case definition and those selected by the surveillance system.

The Likert scale score (Table 15) for representativeness was four out of four points, as it completely met the system objective. The patients who met the case definition were representative of those in the sample, and representative of those with the final surveillance diagnoses chosen.

Summary Likert Score for Characterizing Patient Demographic Characteristics

The overall possible score in this section was 44 points. Eleven unweighted criteria were worth a possible four points each. The system score was 37 points, representing a score of .84 for this section.

OVERALL SYSTEM SUCCESS

The pilot surveillance system, as most fledgling enterprises, has both advantages and disadvantages. Table 15 shows a Likert scale measurement of system success for each of the purposes reviewed previously. Each item in the table is weighted equally because the CDC does not take a position on the importance of each relative to the others, and because no objective data or logical reasons exist to demonstrate that one attribute is worth more than other. Such a decision would have to be largely subjective. One might argue that the operation of the overall system should be weighted more highly, as the difficulty in this area has been the "rate-limiting step." However, should only two of the criteria within system operation change, DHS participation and its workforce stability, the total for the overall system would increase from 22/44 possible points (.50) to 30/44 (.68), and the total for all purposes would increase from 96/136 (.71) to 104/136 (.76). I would argue that this is a respectable score and reflects the potential of the system, despite the difficulties discussed later.

Table 15. Likert Scale Measurement of System Success Meeting CDC Guidelines

Score: Met Objectives	Not at all=0	Slightly=1	Moderately=2	Very well=3	Completely=4
1. Overall System[1]					
Simplicity					
Set-up	X				
Operation					X
Extra training					X
Flexibility					
Data transfer & collection		X			
Scalability		X			
Acceptability					
Agency participation	X				
OHSU reporting rate					X
Timeliness					
Initiation	X				
Stability					
Computer-related					X
OHSU workforce					X
DHS workforce	X				
Subtotal & Total for Overall System	0	2	0	0	20; 22/44=. 50
2. Estimating Cases[2]					
Simplicity					
Developing case definition		X			
Choose/validate surv. definition	X				
Using case definition					X
Flexibility					
Can change case definition					X
Data Quality					
Training of assessors					X
Accuracy data entry					X
Timeliness					
Data transmission rate					X
Acceptability					
Of importance of problem					X
Confidentiality					X
Costs to DHS	X				
Sensitivity >70%					X
PPV>70%					X
Subtotal & Total for Estimating Cases	0	1	0	0	36; 37/48=. 77
3. Characterizing Demographics[3]					
Simplicity					
Data collection					X
Comparative analysis		X			
Integration with other databases	X				
Analysis within the system					X
Flexibility					
Granularity of data					X
Data quality					
Completeness					X
Racial assignment method					X
Concordance					X
Acceptability					
For federal research					X
Sensitivity					
Individual demographics					X
Representativeness					
Met case def. re larger sample					X
Subtotal & Total for Demographics	0	1	0	0	36; 37/44=. 84
Total for All Purposes					96/136= .71

1 and 3: 11 criteria; 2: 12 criteria

EVALUATION OF THE SYSTEM FOR FUTURE PURPOSES

The results presented in the previous sections are derived from the system as it is presently used. As an additional evaluation measure of system performance, I determined whether the system could provide the data to answer some hypothetical questions.

The original system was merely set up to track annual trends. However, in the future it would be possible to focus on analyzing short-term data if desired. One might surmise that asthma ED visits would be more frequent in the cold winter months, when many people have upper respiratory infections (URI's). Then, one could test the null hypothesis that asthma ED visits did not vary significantly by month, season, or type of season as classified by average temperature. Analysis of the 2001 data by chi-square revealed that no significant differences existed in asthma ED visits by month, season, or type of season (Figure 5, Table 16). Although more visits (55) occurred during the colder seasons of winter and spring than occurred during the warmer summer and fall (37), this difference was not significant either (p=.390).

Figure 5. Frequencies of ED Asthma Visits by Month.

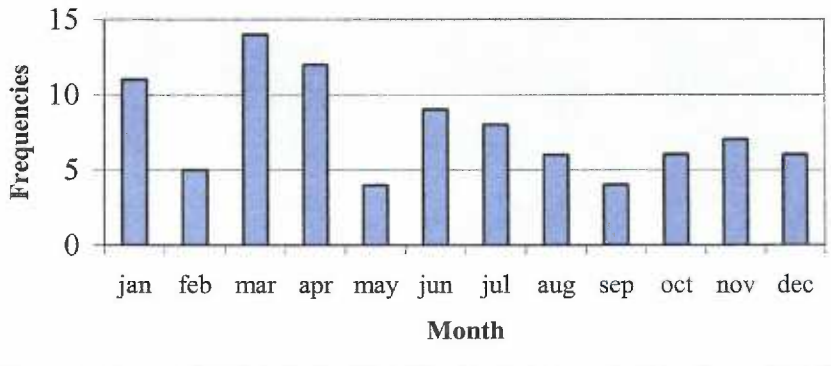


Table 16. ED Asthma Visits by the Month, Season or Type of Season.

Time Interval	Met Case Definition (N=92)	P Value
Month		.065
January	11	
February	5	
March	14	
April	12	
May	4	
June	9	
July	8	
August	6	
September	4	
October	6	
November	7	
December	6	
Season*		.178
Winter	24	
Spring	31	
Summer	21	
Fall	16	
Season "Type"		.390
Cooler*	55	
Warmer**	37	

* Spring = Feb-Apr; summer = May-Jul; fall = Aug-Oct; winter = Nov-Jan.
** Winter, spring
*** Summer, fall

Another potential use for the system addresses the CDC use of surveillance system data to improve clinical practices. The OAP and ADWG are very interested in determining whether ED discharge practices followed the national recommendations as a baseline for quality of care evaluation. The NAEPP guidelines recommend that all asthma ED patients, adult and pediatric, receive a prescription for steroids (34).

Therefore, one could test the null hypothesis that whether a patient receives a steroid upon discharge does not differ significantly according to insurance status. Table 17 shows that 154 of the sampled 177 ED patients were not admitted. Of these, only 66/154 (42.9%) received a steroid prescription upon discharge. Chi square analysis of the

discharged patients shows that only self-pay status was significant for being less likely to receive a steroid on discharge.

Table 17: Whether ED Patients Were Discharged on a Steroid Prescription, Categorized by Insurance Status.

Insurance	Steroid Prescription			P value
	Yes	No	Admitted**	
Medicaid	32	40	24	.592
Medicare	7	8	4	.714
Private	16	13	8	.114
Self-pay	4	22	0	**.002**
Unknown	7	5	2	**
Total*	66	88	38	

*Total N=192, because some had both Medicaid and Medicare
** Not included in analysis

The NAEPP guidelines on ED discharge management also state that all patients seen for emergent asthma visits receive a referral to a primary care provider (PCP) within 1 week. One might hypothesize that clinicians would have doubts about the ability of patients without insurance to see a provider for follow-up after the ED visit, and might thus decline to arrange such follow-up. The null hypothesis would be that whether or not patients receive appointments for follow-up visits does not differ significantly according to insurance status. Table 18 shows that of the 154 patients not admitted to the hospital, no significant differences exist according to insurance status as to whether the follow-up appointments are made.

Table 18. Whether ED Patients Received a Follow-Up Appointment, Categorized by Insurance Status.

Insurance	Follow-Up Appointment			P value
	Yes	No	Admitted**	
Medicaid	31	41	24	.242
Medicare	7	8	4	.920
Private	19	10	8	.033
Self-pay	9	17	0	.134
Unknown	7	5	2	**
Total*	73	81	38	

*Total N= 192; some patients had both Medicaid and Medicare
** Not included in analysis

Such data could obviously serve as a foundation for clinician education within OHSU ED. Additionally, dissemination of results would aid the ADWG and OAN to design statewide ED asthma materials.

DISCUSSION

Evaluation of a pilot surveillance system is difficult. The CDC guidelines are not absolutes, and are intended for established systems, not pilot systems. However, because of the lack of definitive criteria otherwise, these criteria do have the advantage of providing a comprehensive method of judging whether the system achieves its goals without excessive costs. Other methods of evaluation, such as those provided by the Public Health Conceptual Data Model (PHCDM) or in the CDC's 1999 Framework for Program Evaluation, appear to require significant personnel input by those with extensive informatics sophistication (76-77).

The advantages of this pilot surveillance system, as mentioned previously, were its ease of use for clinicians, the maintenance of patient confidentiality, the completely automated nature of the data transmission, and the avoidance of the limitations of self-report and billing records to obtain data. And, despite its current limitations, it holds much promise for the future. First, it already fulfills the five of the six criteria that the PHCDM suggested (76) for the integration of public health information and surveillance systems (Table 19). It is built on a previously existing patient care system, it utilizes a pre-existing electronic surveillance system, data collection is automatic without any burden

Table 19. Public Health Conceptual Data Model Recommendations for Integration of Public Health Information and Surveillance Systems

1. Build on the patient care, client management, or other systems already in place or under development by health care providers, public health agencies, or others.
2. Build new systems when necessary to meet critical needs, but only within a larger coordinated approach.
3. Minimize the collection and reporting burden placed on providers of data, as data should be collected once and then shared efficiently to meet all legitimate needs for these data.
4. Minimize the effort required to reformat, transmit, and share data with users.
5. Build on data systems that have already been established, by modifying or augmenting existing surveys or surveillance systems
6. Maximize the protection of confidentiality and minimize the potential for inadvertent, inappropriate, or other potentially harmful release of information.

on providers, the use of HL-7 precludes any need for data reformatting, and extensive security and privacy measures are in place.

Despite these promising qualities, serious limitations exist. Currently, one limitation of the system is its ability to provide numbers representative of asthma ED visits in the county. Obtaining an accurate estimate of the numbers of patients with ED asthma visits in Multnomah County cannot be obtained only by using only the OHSU site. It would necessitate obtaining the numbers of patients seen at the remaining ED's in the county. This would require that the same type of system be dispersed at all of the other ED's in the county. Thus far, the OHSU ED is the only Multnomah County ED to have this surveillance system in place. Plans are underway to expand this project to other institutions, but the expansion is still in the preliminary phases. Therefore, at this time the state health department cannot accurately estimate the desired numbers. It would have been desirable to make a more educated guess about the total numbers of asthma ED visits by obtaining statistics from these ED's, but these were not made available to the author. Even if they had been, without case validation the numbers would not necessarily represent asthma visits. Additionally, the Asthma Data Work Group members do not as yet have these figures. At this time, the numbers we obtain can simply be regarded as an approximation of the numbers of patients visiting the OHSU ED for asthma exacerbations annually.

Recommendations to improve the surveillance system are not practical in the current financial climate. If funding were available, the system could utilize the four strategies

(Table 20) suggested for improving information management in emergency medicine (33).

Table 20. Recommended Strategies for Improving ED Information Management to Meet Clinical, Research, and Administrative Needs

1. The evolution of standards and uniform data sets should be funded and promoted.
2. Health care information systems should be integrated to meet clinical, management, and research needs.
3. Health care professionals should be trained to use information technologies to transform data into information.
4. Future trends, opportunities, and risks regarding information technologies should be systematically studied.

In addition to the above, the Frontlines of Medicine Project also recommends interactive communication. After data from the surveillance system are analyzed, the system ideally would trigger follow-up questions or educational materials back to the provider (31).

Aside from monetary considerations, the ADWG feels that some of the limitations are that the system is not implemented state-wide, it is difficult to determine a meaningful denominator, and the types of data that can be obtained do not help them to measure the relevant priority population based indicators (Table 21) in the Guide to Improving Asthma Care in Oregon (29).

Table 21. Guide to Improving Asthma Care in Oregon. Indicator III: Coordination of Care.

A successful program will show an increase in the percent of people with one emergency department (ED) visit who are seen by a medical practitioner within one month of the ED visit.
A successful program will show an increase in the percent of people with two emergency department (ED) visits for asthma in 12 months who are seen by an asthma specialist within one month of the most recent ED visit.

The need for wider dispersion of a surveillance system has already been discussed. Additionally, if sufficient funding were available, the following measures warrant

consideration. To obtain the data needed for the indicators, an asthma outreach specialist position should be created to track the ED visits, conduct standardized chart audits, and ensure that follow-up has been arranged. If needed, the ED should provide the medications and transportation vouchers if necessary (78-79). Some ED's in large cities have already implemented such measures, with encouraging results.

CONCLUSION

The system cannot fully satisfy the CDC goals of ease of operation or simplicity of structure. Although simple to operate at the OHSU site, the original requirements for setup were challenging and likely would be prohibitive to smaller institutions. The case definition was difficult to choose and validate. However, once this was accomplished, the resultant surveillance definition was very easy to use. The system easily captures demographic data, although, as discussed previously, its interpretation will be more problematic.

The current system is very flexible in its ability to accommodate changes in case definition that would affect estimation of the numbers affected. However, the system has only moderate flexibility for the data transfer process because of its lack of ease of integration into other systems, lack of scalability and its need for sophisticated personnel. It does, however, have the capacity to respond to changing information needs on demographics because of the fine level of data granularity.

Acceptability to the clinicians is high, as witnessed by the 100% reporting rate. The system's HIPAA compliance renders it acceptable to the participating hospital. In theory, the system is acceptable to the state, which desires the data in order to plan their preventive programs and interventions. However, the human resource and financial costs made it completely impractical and unacceptable at the time of this evaluation.

The initiation of the system was not timely, and currently the data analysis lacks timeliness as well due to financial constraints in the state. However, because the data are transmitted weekly, the system does possess the timeliness to provide the state with an ability to compare the frequencies of the emergent asthma visits with the yearly data provided by other sources such as the managed care organizations or the BRFSS data.

Stability is one of the more problematic aspects in this surveillance system. Server crashes are now infrequent and remain only a minor source of instability. The major problem lies in the state's lack of financial ability to maintain staff to perform data analysis, management, and dissemination.

The surveillance system data are generally of high quality because of completeness and validity with regard to estimating the numbers of cases of incident asthma seen at OHSU, and determining the relevant demographics. However, because the data are derived from only one site, OHSU ED, it cannot be said to be anything other than an estimate of ED asthma visits at that particular site. Nevertheless, that estimate could still be used to track changes in the numbers or demographics with respect to seasonal changes or environmental risk factors for asthma.

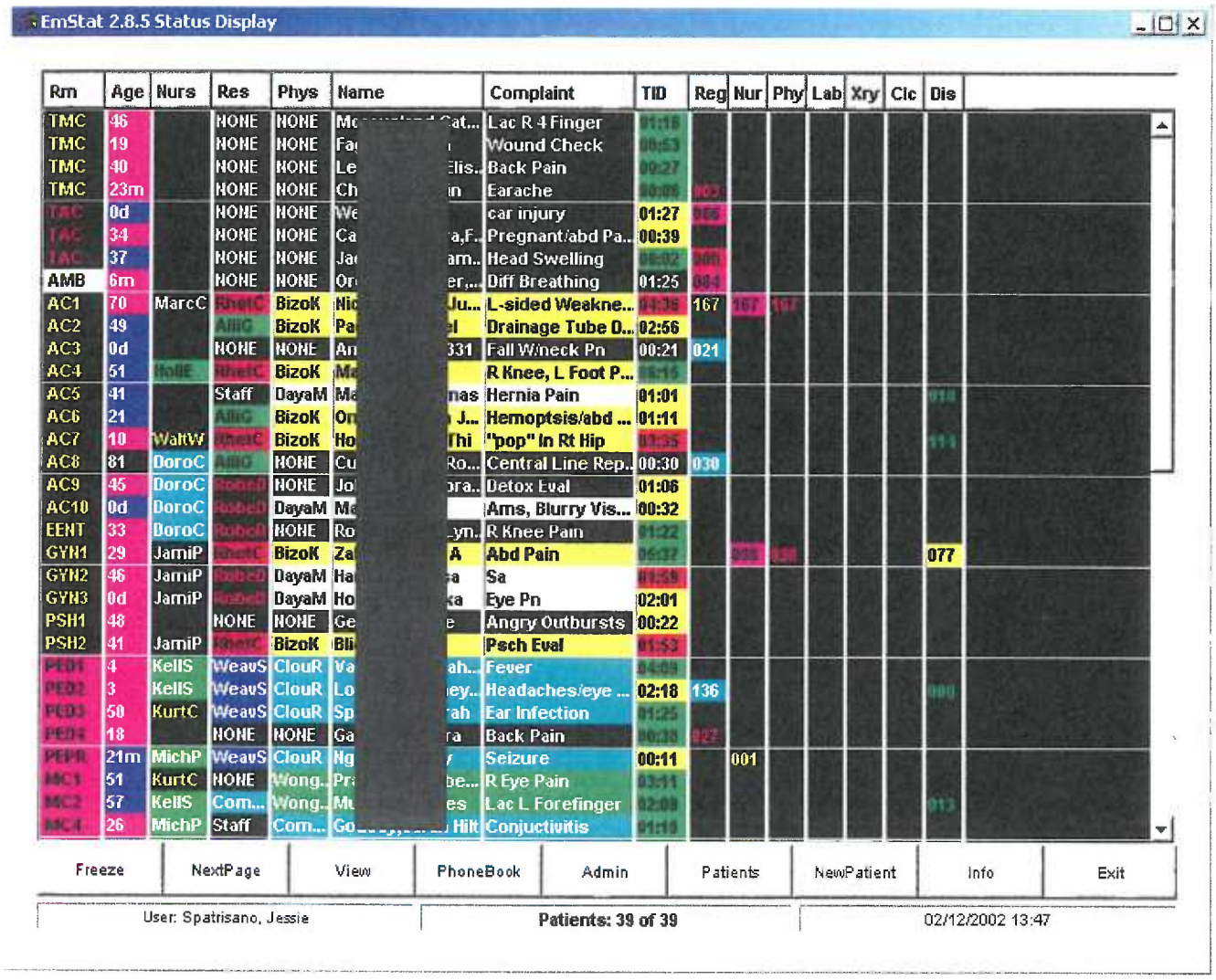
The system is certainly successful at providing a high degree of sensitivity and PPV. By aggregating some of the EmSTAT diagnoses, I was able to produce a surveillance case definition that provided a sensitivity of 78.3%, and a PPV of 80%.

The system was able to capture a representative demographic sample of the larger population visiting the OHSU ED for diagnoses compatible with asthma. However, it cannot be determined whether the cases are representative of any larger population.

Overall, the system would fulfill the four CDC criteria for utility if a DHS epidemiologist were available and if it could be expanded to other sites (Table 2). It has the capacity to detect a serious public health problem in a timely manner, providing that the problem affects the population served by the OHSU ED. It provides at least a minimal estimate of the magnitude of morbidity, and could provide a more accurate estimate if adopted by other ED's in the county serving that population. It can provide data useful for detection of short-term and annual temporal trends.

Lastly, because it contains data elements for discharge medications and follow-up recommendations, it certainly could serve as a basis for programs to improve clinical practices. Asthma care in emergency departments has improved since 1996 but still does not meet national standards. Reasons include unfamiliarity with guidelines, steroid phobia, and lack of agreement with the consensus opinion or its practicality (80-83).

APPENDIX A


EmStat 2.8.5 Status Display
Rm | Age | Nurs | Res | Phys | Name | Complaint | TID | Reg | Nur | Phy | Lab | Xry | Clc | Dis
TMC | 46 | | NONE | NONE | Lac R 4 Finger
TMC | 19 | | NONE | NONE | Wound Check
TMC | 40 | | NONE | NONE | Back Pain
TMC | 23m | | NONE | NONE | Earache
0d | | NONE | NONE | car injury | 01:27
34 | | NONE | NONE | Pregnant/abd Pa.. | 00:39
37 | | NONE | NONE | Head Swelling
AMB | 6m | | NONE | NONE | Diff Breathing | 01:25
AC1 | 70 | MarcC | BizoK | L-sided Weakne.. | 167
AC2 | 49 | | BizoK | Drainage Tube D... | 02:56
AC3 | 0d | | NONE | NONE | Fall W/neck Pn | 00:21 | 021
AC4 | 51 | | BizoK | R Knee, L Foot P...
AC5 | 41 | | Staff | DayaM | Hernia Pain | 01:01
AC6 | 21 | | BizoK | Hemoptsis/abd ... | 01:11
AC7 | 10 | WaltW | BizoK | "pop" In Rt Hip
AC8 | 81 | DoroC | NONE | Central Line Rep.. | 00:30 | 030
AC9 | 45 | DoroC | NONE | Detox Eval | 01:06
AC10 | 0d | DoroC | DayaM | Ams, Blurry Vis... | 00:32
EENT | 33 | DoroC | NONE | R Knee Pain
GYN1 | 29 | JamiP | BizoK | Abd Pain | 077
GYN2 | 46 | JamiP | DayaM | Sa
GYN3 | 0d | JamiP | DayaM | Eye Pn | 02:01
PSH1 | 48 | | NONE | NONE | Angry Outbursts | 00:22
PSH2 | 41 | JamiP | BizoK | Psch Eval
PED1 | 4 | KellS | WeauS | ClouR | Fever
PED2 | 3 | KellS | WeauS | ClouR | Headaches/eye ... | 02:18 | 136
PED3 | 50 | KurtC | WeauS | ClouR | Ear Infection
PED4 | 18 | | NONE | NONE | Back Pain
PEPR | 21m | MichP | WeauS | ClouR | Seizure | 00:11 | 001
MC1 | 51 | KurtC | NONE | Wong.. | R Eye Pain
MC2 | 57 | KellS | Com... | Wong.. | Lac L Forefinger
MC4 | 26 | MichP | Staff | Com... | Conjuctivitis
Freeze | NextPage | View | PhoneBook | Admin | Patients | NewPatient | Info | Exit
User: Spatrisano, Jessie
Patients: 39 of 39
02/12/2002 13:47

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