Surveillance System for Early Detection of Influenza-Like Illness (ILI) Outbreaks Based on Participatory Report of Student Absences

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***Abstract* — One of the serious problems in health sector is the existence of disease outbreaks that may increase rapidly, especially when the signs of outbreaks or potential outbreaks are too late to detect. People who perceive mild symptoms of illness are usually reluctant to go to any health units though these could be the early signs of a more serious one. Therefore, latest information from citizens about the symptoms of disease that are emerging in their nearby environment is necessary. This research proposes a surveillance system for monitoring the existence of a contagious disease known as *Influenza-Like Illness* (ILI). The system is designed as a participatory application that enables authorized citizens, such as high school health personnel, to report students who do not come to school because of illness along with the perceived complaints. The outcome of this research is a geographic information system that allows the health authority to detect areas affected by ILI outbreak, to analyze the spatial and temporal distribution of ILI occurrences, and to analyze the trend of data distribution presented as descriptive epidemiology reports. This research shows that participatory reports on a limited sample of data can be utilized to generate a surveillance system that is simple, flexible, and quick at recognizing the existence of disease outbreaks.**

***Keywords*—** Contagious, Disease, Epidemiology, School

I. INTRODUCTION

One of the serious problems in health sector in Indonesia is disease outbreaks. Indonesia experiences outbreaks of infectious diseases almost every year. This is triggered by the population density, tropical climate, and poor health infrastructure that enable the re-emergence of infectious diseases. Another factor comes from humans. Normally, people who perceive mild symptoms of disease, such as fever, cough, and/or body aches, are reluctant to visit doctors in any kind of health units [1]. These symptoms can eventually become early signs of a more serious disease, which may increase the number of people infected, especially when the information about the existence of these symptoms in the society is too late to detect.

Influenza is one of the highly contagious diseases caused by the influenza virus and has several levels of pain from mild to severe or may even cause death. Influenza becomes a serious illness since it is transmitted through the human respiratory system. In addition, this disease may also be easily transmitted among humans, or humans and animals, and has developed a wide range of variants of the virus, such as H1N1 that is also known as avian influenza [2].

One province in Indonesia that is quite susceptible to influenza disease transmission is Yogyakarta City. In the year 2009, Yogyakarta City had an episode of influenza outbreaks, which was growing very fast and out of control. Reports from the local health centers showed that the highest number of visits came from patients with the age range between 15 – 20 years old. A comprehensive study that was conducted in the same period also found a high rate of high school students who were absent from school because of illness. Based on the interviews with the school health units, the most common symptoms perceived by these students were fever, headache, myalgia, lethargy, coryza (sneezing and runny nose), sore throat, and cough. This study showed a strong correlation between the number of students who did not go to school because of illness and the influenza outbreaks [3].

Controlling infectious and non-infectious diseases requires a surveillance-response system that is simple, flexible, easily accepted, reliable, and time-saving [4], [5]. Surveillance or reporting system that is followed by responses also aims for early detection of an outbreak or potential outbreaks. The existence of this system is highly needed with regard to the handling actions that must be performed as soon as possible to minimize the number of people infected and to reduce the amount of handling costs.

Indonesia has a similar surveillance-response system named EWARS (Early Warning and Response System) that has been applied in 23 provinces [6]. In this program, the surveillance personnel are required to report on a weekly basis the number of disease occurrences in their respective work areas. Based on the processing of accumulated data, the existence of an outbreak can be detected hierarchically from the lowest level of health unit in a region up to the national one. However, the hierarchical mechanism of reporting and the number of personnel that should be involved have resulted in a variety of problems. These problems especially deal with some data that have not been covered yet, such as the number of patient visits to private clinics, data processing that has not been performed at all levels of health units, irregularity of data analysis and interpretation, and feedback of submitted reports that are considered time-consuming [6], [7]. Therefore, the nature of a surveillance-response system, which is simple, flexible, and quick at detecting disease outbreaks, has not been fully implemented.

This paper proposes a web-based surveillance system to monitor the occurrence of ILI in the district or municipality level. The system is designed as a participatory application that enables the citizens to report the emergence of ILI symptoms in their nearby environment. The ILI occurrences are based on the reports of high school students who do not come to school because of illness and have the perceived complaints that are in conjunction with ILI symptoms. The system outcomes are intended for the health authority to detect the areas affected by ILI outbreaks rapidly and to analyze the trend of ILI occurrences based on its spatial and temporal distributions. This research shows that participatory reports on a limited sample of data can be utilized to generate a surveillance system that is simple, flexible, and quick at recognizing the existence of disease outbreaks.

II. RELATED WORKS

The Ministry of Health of Indonesia in cooperation with WHO and the United States Centers for Disease Control and Prevention (US CDC) have developed a program named EWARS (Early Warning and Response System). It is a computer network-based system that requires the local surveillance personnel in the district level (Puskesmas) to send reports on a weekly basis to the higher level of governmental health units, in which the district level send data to the provincial level, and the accumulated data in the provincial level will be sent to the national ones. Currently, 21 types of symptoms of potential outbreaks should be reported using a specific code and SMS (Short Messages Service) format. The output of this report can be presented as tables, graphs, and maps, which can be utilized by the higher health institutions to respond or conduct some actions when the number of cases exceeds the threshold value. This is an effective program since the surveillance personnel are able to detect the existence of an outbreak in their respective work areas quickly, so that the incidence can be handled swiftly and may not have a wide impact on the society. However, there are still some problems in conjunction with the completeness and the timeliness of reporting that takes some amount of time for obtaining the results of data analysis [6], [7].

Another specific surveillance-response system is applied in the district of Malang, East Java, where the local government gives serious attention to maternal and child health programs. The program named Sijari Emas is a system for detection and early warning of non-contagious diseases that potentially threaten maternal and child mortality. This system enables health volunteers at the neighborhood level to report the residents' illnesses in their territory by using SMS-based technology. The incoming reports will be passed on by the district tocologist to the health department server. When the number of reports exceeds the prescribed limit, the data server will turn on the alarm on the location of areas affected by the outbreak [8].

III. MATERIALS AND METHODS

The research subjects were high school students in the municipality of Yogyakarta City, Indonesia primarily students who were absent from school because of illness and had perceived complaints in accordance with ILI symptoms. The ILI symptoms consist of cough, fever, sniffles, whacked, body aches, headache, sore throat, shortness of breath, diarrhea, and nausea [1].

The Participatory surveillance system was designed as a geographic information system that is able to show the spatial and temporal characteristics of its dataset. To visualize the spatial distribution, this research classified the dataset into 3 (three) categories. This classification was based on the theory of quartile that separates each 25% of data frequency following the equations (1) – (3) below [9]:

$$\kappa 1 = 1/4 * (N + 1) \quad (1)$$

$$\kappa 2 = 1/2 * (N+1) \quad (2)$$

$$\kappa 3 = 3/4 * (N+1) \quad (3)$$

Note: N = number of data

An example is given to categorize the number of ILI occurrences of 10 high schools as shown in Table I. The first step was sorting the dataset, and the result should be as shown in Table II. The second step was determining the quartile (K) values based on (1) – (3), and it was found that K1 was 2.75, K2 was 5.5, and K3 was 8.25. These K values would be used in the third step, which was defining the boundary for each category. The 1st boundary was the data on the 2.75th or 3th position (value 7), the 2nd boundary was the data on the 5.5th or 6th position (value 10), and the 3rd boundary was the data on the 8.25th or 8th position (value 12). The fourth step, mapping the results, defined: (a) category 1 for number of occurrences <= 7, (b) category 2 for number of occurrences > 7 and <12, and (c) category 3 for number of occurrences >= 12.

TABLE I. NUMBER OF ILI OCCURRENCES

High School	HS1	HS2	HS3	HS4	HS5	HS6	HS7	HS8	HS9	HS-10
Data Value	10	8	12	15	7	12	7	11	6	7

TABLE II. RESULT OF DATA SORTING

Position	1	2	3	4	5	6	7	8	9	10
High School	HS9	HS5	HS7	HS-10	HS2	HS1	HS8	HS3	HS6	HS4
Data Value	6	7	7	7	8	10	11	12	12	15

IV. RESULTS AND DISCUSSION

The surveillance system for monitoring ILI occurrences is implemented as a web-based application with the general workflow shown in Fig. 1. This system involves 3 (three) types of users, i.e. administrator, school health personnel, and health authority.

Administrator is a system manager that has responsibilities to manage the user accounts, school entities, and symptoms of disease. School health personnel act as data providers that actively report their students who do not come to school because of illness and the perceived complaints. If the complaints are in accordance with ILI symptoms, they will be considered as a case of ILI. The system will process these participatory reports to generate 3 (three) types of output that can be accessed by the health authority: (a) outbreak notification, (b) the trend of ILI occurrences which is presented as descriptive epidemiology reports, and (c) analysis of spatial distribution based on the number of disease occurrences.

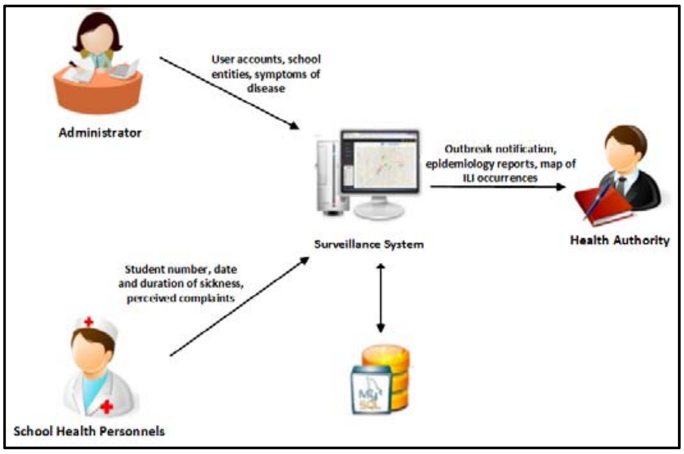

Fig. 1. General System Workflow

A. Participatory Reports

This system relies heavily on the participatory reports from the citizens. To obtain valid information, the data providers are limited to the authorized ones, which are school health personnel, to report their absent students on a daily basis. The form of web-based participatory reports can be seen in Fig 2. There are some key information items required, including the student number (to generate students' address, age, and gender), the perceived complaints, the first day of sickness, and the duration of illness.

B. Outbreak Notification

The outbreak status is governed by the Regulation of the Indonesia Ministry of Health No. 949 in 2004 that includes seven criteria in which one criterion mentions the increased incidence of cases occurring two times or more compared to the previous period that can be in hours, days, or weeks [10]. In this research, the outbreak status was based on the comparison of accumulated data on a weekly basis. If the number of cases in the current week increases by 100% or more compared to the previous week, it can be declared that there has been an outbreak.

The outbreak notification is visualized in the form of map, which has two contrast-color associations, which are red color indicating the outbreak area and green color marking the normal condition. The notification map consists of all districts in the research area, so one district represents the accumulated data on a weekly basis from all schools that are registered in the respective district.

As shown in Fig 3, two districts on the present date are visualized in red. This may imply that the number of ILI occurrences in both areas has a two-fold increment compared to the data accumulation in the previous week. This contrast-color visualization is considered as an effective, essential mechanism since it may also work as an alert system that rapidly informs the existence of ILI outbreak.

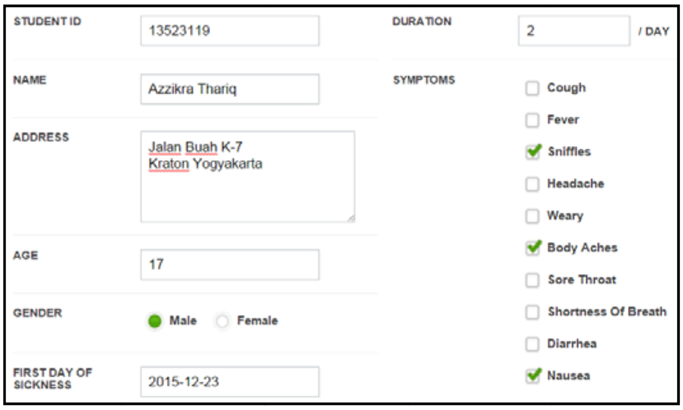
STUDENT ID: 13523119
NAME: Azzikra Thariq
ADDRESS: Jalan Buah K-7 Kraton Yogyakarta
AGE: 17
GENDER: Male / Female
FIRST DAY OF SICKNESS: 2015-12-23
DURATION: 2 / DAY
SYMPTOMS: Cough, Fever, Sniffles, Headache, Weary, Body Aches, Sore Throat, Shortness Of Breath, Diarrhea, Nausea

Fig. 2. Form of Participatory Report

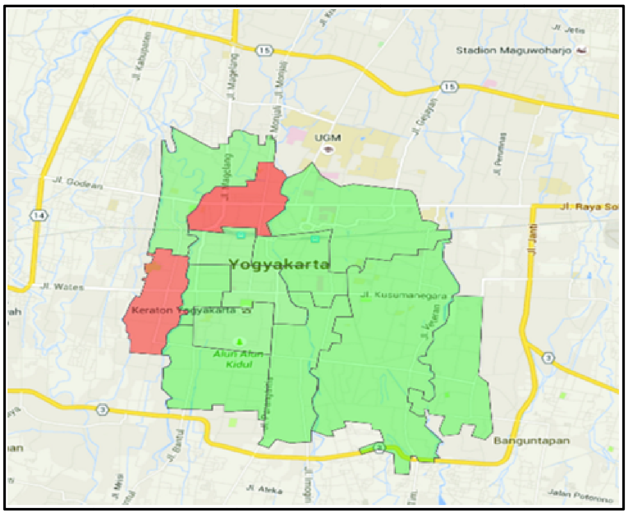

Fig. 3. Map of Outbreak Notification

C. Analysis of Spatial Distribution

The analysis of spatial distribution is intended to illustrate the distribution of ILI occurrences, which is tailored to the geographic location of schools. Each school is symbolized by a point and associated with a particular category of data, in which green shows smaller amounts, yellow represents moderate amounts, and red states greater amounts. The data categorization is based on the theory of quartile and follows (1) – (3) to define the class boundary. The school category and the boundary for each category may change dynamically since this system enables users to specify the time and the location of interest.

The example given in Fig 4 illustrates the number distribution of ILI occurrences for the whole districts in the municipality of Yogyakarta City from June 1 to 14, 2015. On the left bottom of the map, there is a legend showing the boundaries of each class. The Green marker applies to schools that have less or equal to 1 (one) ILI occurrence, Yellow marker works for those having between 1 (one) and 3 (three) occurrences, and those with more or equal to 3 (three) occurrences will be marked as Red. Furthermore, in this figure, users may have a slight visual inspection and find that higher ILI occurrences, the red markers, are located in the northern part of the city.

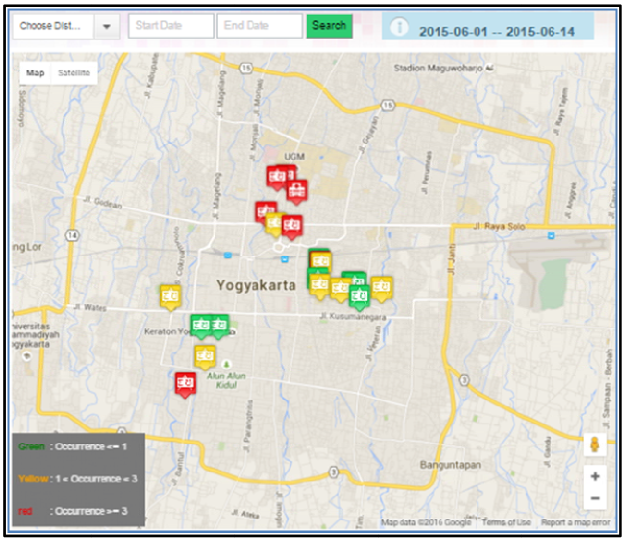

Fig. 4. Map of Spatial Distribution

D. Analysis of Descriptive Epidemiology

The analysis of descriptive epidemiology is intended to illustrate the trend of ILI frequency and its distribution. This analysis is essential for detecting the sudden cases, such as an epidemic, in terms of how common an illness is with reference to the size of object population and a period of time [10]. Descriptive epidemiology commonly answers the questions of who, where, and when. In this research, the who questions are based on the gender and age distributions, the where questions are based on the high school and district locations, and the when questions are applied to any specified dates of interest.

The analysis of gender distributions can be based on any specified location and time. The example given in Fig 5 shows the pie chart of ILI sufferers' gender distribution in the district of Umbulharjo from June 1 to 14, 2015. As seen here, the ILI cases were mostly attached to female since it held 60% of the total distribution (6 out of 10 students). Further information may also be accessed by clicking the chart to find the data distribution based on the student's school of origin and the date of ILI occurrences.

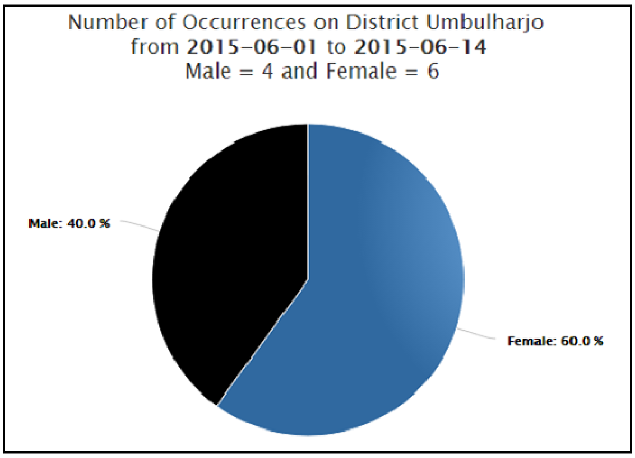

Fig. 5. Descriptive Epidemiology Based on Gender

The analysis of age distributions can also be based on any specified location and time. For example, in Fig 6, with the same criteria, in Umbulharjo District from June 1 to 14, 2015, the ILI cases were mostly attached to age 17 (40%) and 19 (also 40%). By clicking the chart on any ages, users may find more details of data distribution based on the school and the week of ILI occurrences.

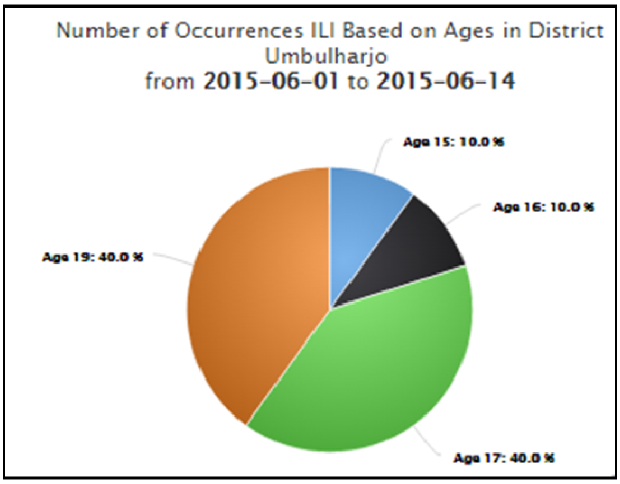

Fig. 6. Descriptive Epidemiology Based on Ages

The descriptive epidemiology based on place is illustrated as the comparison of ILI occurrences among the schools in the specified district and time. The comparative data are presented as a bar chart in which x-axis declares the school's names and y-axis represents the number of occurrences. The example given in Fig 7 shows the bar chart of schools located in Umbulharjo. The comparisons were applied to the number of ILI occurrences from June 1 to 14, 2015. Based on this graph, users can analyze which school has the highest and the lowest number of ILI occurrences. In addition, users may also inspect whether any anomalies occur in the dataset, such as values that are far above the average.

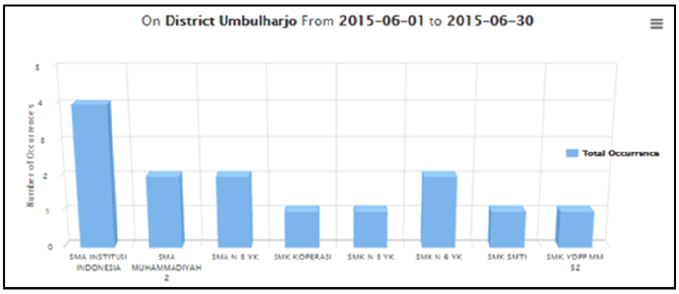

Fig. 7. Descriptive Epidemiology Based on High School Locations

Another option to analyze the trend of ILI occurrences can also be done by its time of occurrences. For example, as shown in Fig 8, users may have the comparative data of ILI occurrences in all districts of Yogyakarta City from June 1 to 30, 2015. The data are illustrated as a bar chart on a daily basis. In that figure, users may notify the trend of ILI occurrences from day to day and inspect when the highest number of ILI occurs.

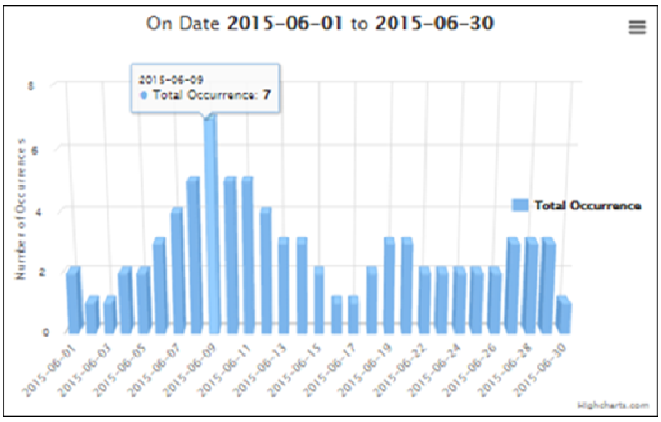

Fig. 8. Descriptive Epidemiology Based on Time of Occurrences

V. CONCLUSIONS

Based on the findings and system evaluation, there are some conclusions that can be drawn as follow:

- Participatory surveillance system has been implemented as a web-based geographic information system that involves 3 (three) types of users, including administrator as a system manager, school health personnel as data providers, and the health authority as the examiner of system outputs.
- As a participatory-based application, it relies heavily on the number of incoming reports that are actively provided by the citizens. Therefore, the amount of information received will determine the accuracy level of system outcomes. However, the validity of information can be guaranteed since it comes from the parties that are authorized to provide such information.
- This research has shown that participatory report based on data of student absences can be utilized to generate a surveillance system that enables the health authority to detect areas affected by disease outbreaks and to monitor the trend of disease occurrences in any specified time and locations.

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References

[1] D. Paolotti, a. Carnahan, V. Colizza, K. Eames, J. Edmunds, G. Gomes, C. Koppeschaar, M. Rehn, R. Smallenburg, C. Turbelin, S. Van Noort, and a. Vespignani, “Web-based participatory surveillance of infectious diseases: The Influenzanet participatory surveillance experience,” Clin. Microbiol. Infect., vol. 20, no. 1, pp. 17–21, 2014.

[2] N. J. Cox, “Natural History of Disease and Biological Aspects of Influenza A (H1N1),” US Centers for Disease Control and Prevention, 2009. [Online]. Available: http://www.insp.mx/encuentroh1n1/ponencias/cox_nancy.pdf. [Accessed: 10-Dec-2014].

[3] M. Nurbeti, “The investigation report outbreaks of Influenza Like Illness (ILI) in Sub Gondokusuman, Kraton, Umbulharjo and Matrijeron Yogyakarta (Research Reports Field Epidemiology),” Yogyakarta, 2009.

[4] L. M. Lee, Principle and Practice of Public Health Surveillance. Oxford University Press, 2010.

[5] C. C. Jost, J. C. Mariner, P. L. Roeder, E. Sawitri, and G. J. Macgregor-Skinner, “Participatory epidemiology in disease surveillance and research.,” Rev. Sci. Tech., vol. 26, no. 3, pp. 537–549, 2007.

[6] S. Y. Mei, “Evaluation of Utilization of Early Warning Alert and Response System (Ewars) in the District Boyolali,” GADJAH MADA UNIVERSITY, Yogyakarta, 2015.

[7] M. Arsyam, “Evaluation of Application Based Surveillance Information System (EWARS) in Early Detection Efforts Extraordinary Events in Barru, Indonesia,” Gadjah Mada University, 2013.

[8] “Sutera Emas and Sijari Emas, Health Program of Maternal and Child Health in Malang,” Malang Post. [Online]. Available: http://www.malang-post.com/metro-raya/70373-sutera-emas-ikon-kabupaten-malang-untuk-dunia. [Accessed: 01-Dec-2014].

[9] H. Sutrisno, Basic Statistics. Yogyakarta: ANDI OFFSET, 1997.

[10] J. Lombardo, H. Burkom, E. E. Elbert, S. Magruder, S. Happel Lewis, W. Loschen, J. Sari, C. Sniegoski, R. Wojcik, and J. Pavlin, “A Systems Overview of the Electronic Surveillance System for the Early Notification of Community-Based Epidemics (ESSENCE II),” J. Urban Heal. Bull. New York Acad. Med., vol. 80, no. 2 Supplement 1, 2003.