

# Leveraging surveillance technology to benefit the practice and profession of infection control

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**Background:** Surveillance for health care-acquired infections is the cornerstone of an effective infection control program. Historically, a key case finding methodology for surveillance activity has been the manual review of computerized microbiology reports performed by trained infection control professionals (ICPs). But this process is labor-intensive and diverts a substantial amount of time from the ICPs' consultative and educational responsibilities.

**Methods:** The evaluation of an automated system for surveillance included a review of surveillance objectives, creation of a "wish list" of functions to be performed by an automated system, and identification and evaluation of available systems.

**Results:** An automated surveillance system with defined single-event alerts and process control chart analyses to guide surveillance activity improved the management and analysis of surveillance data, leading to improved resource utilization and timely detection of potential outbreaks.

**Conclusions:** An automated surveillance system can facilitate efficient review of data, promote rapid identification of sentinel events and outbreaks, and allow ICPs to pay more attention to education and performance improvement initiatives. (*Am J Infect Control* 2008;36:S7-11.)

The primary goal of an infection control program is to prevent and control health care-associated infections (HAIs). Surveillance—the process of detecting these infections—is the cornerstone of an effective program. Reducing the impact of HAIs requires the ability to identify increases in endemic infection rates, recognize adverse trends, and assess the efficacy of performance improvement initiatives. Historically, a key case finding methodology for surveillance activity has been the manual review of computerized microbiology reports performed by trained infection control professionals (ICPs). But this process is labor-intensive and diverts a substantial amount of time from the ICPs' consultative and educational responsibilities.

Over the past decade, various commercial automated surveillance systems have been developed and marketed. "Automated surveillance" is a generic term

for the process of obtaining useful information from large interrelated databases by identifying abnormal distributions of variables within a defined setting.<sup>1</sup> The databases commonly used for infection surveillance activity are the laboratory information system, admission-transfer-discharge (ADT) database, pharmacy database, and, if available, the electronic medical record. The laboratory information system is used to access microbiology culture data, along with other relevant test results ordered for the assessment of infection (eg, white blood cell count with differential). The ADT database provides information on patient demographics and location within the health care facility. The pharmacy database is used to determine the ordering and administration of antimicrobial agents. Automated surveillance of clinical and administrative information facilitates efficient review of the data and promotes rapid identification of sentinel events and detection of outbreaks.

The University of Maryland Medical Center (UMMC) is a 656-bed tertiary care academic medical center with adult and pediatric patients located in Baltimore, Maryland. UMMC's Infection Control Department consists of a full-time medical director, department director, 3 full-time ICPs, a part-time data analyst, a part-time administrative assistant, and a consultative service from 2 associate hospital epidemiologists from the University of Maryland School of Medicine Department of Epidemiology and Preventive Medicine. In 2001, the

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department beta-tested and subsequently implemented an automated surveillance system (SETNET; Cereplex, Inc, Germantown, MD) designed to manage and analyze surveillance information more efficiently. This article briefly describes the methodology followed when choosing this surveillance system and details the system's functionality in our infection control program's daily operations.

## METHODS

As described by Gaynes et al,<sup>2</sup> the process for evaluating an automated system for surveillance involves 5 steps: (1) evaluating surveillance objectives, (2) reviewing the current surveillance system for its advantages and disadvantages, (3) preparing a "wish list" of functions that an automated system should perform, (4) identifying available systems, and (5) evaluating available systems. At the time we began our search for an automated system, the surveillance plan at UMMC was designed to focus on high-risk patient populations (specifically patients in intensive care units and oncology units, and those undergoing surgical procedures), as well as health care-associated infections resulting in significant morbidity and mortality (eg, bloodstream, pneumonia, and surgical site infections). Surveillance also included the identification of positive microbiology cultures for antibiotic-resistant organisms and for organisms that must be reported to the Maryland Department of Health and Mental Hygiene (DHMH).

Our surveillance process at UMMC primarily involved a daily manual review of all positive microbiology cultures, which required sorting by the ICPs. Not only did this task take approximately 8 hours per week of ICP time, but the division of this work among the 3 ICPs individuals did not allow for efficient identification of potential clusters of infections or sentinel organisms. In addition, because the microbiology report contained all positive cultures, time was allocated to review culture data that were not relevant to our infection surveillance objectives; for example, identifying positive blood cultures obtained in the first 24 hours after admission is not relevant to the calculation of a bloodstream infection rate.

An adjunct surveillance methodology for our infection control program involved the use of microbiology, pharmacy, and ADT data available in a central data repository. This database was used for retrospective data queries, which give immediate results. The use of this database was limited for prospective surveillance and required that the user be trained in data extraction and data reporting methods.

Based on an evaluation of our surveillance objectives and a review of our surveillance methodologies, we created a "wish list" of functions for an automated

surveillance system. We were looking for a system with the following features:

1. The ability to extract and transform laboratory and ADT data from the UMMC databases into readily available and comprehensible information for use by the infection control staff. Specifically, the automated system would provide line listings of patients with positive cultures that could be sorted by site, patient location, and organism.
2. The ability to perform process control chart analyses with patient-days, to help distinguish random variation of events from a cluster or outbreak situation.
3. The ability to generate electronic notifications of sentinel events established by individual users.
4. The ability to generate antibiogram reports for use by clinicians making decisions about empiric antibiotic therapy.
5. Internet-based through a secure server that complies with the Health Insurance Portability and Accountability Act (HIPAA) requirements to ensure patient confidentiality.
6. Marketed by a vendor that solicits user feedback and makes improvements based on that feedback to continually improve system functionality.

We identified and evaluated available systems by soliciting information from other tertiary care academic medical centers that use automated surveillance and by conducting a thorough literature review. At that time, we considered 3 systems, 1 of which was SETNET in an early development stage. Key factors in the decision to beta-test this software included the product's ability to meet our surveillance objectives and to provide automated encrypted data transfer between the medical center and the vendor, as well as its cost. (It is important that a budget for an automated surveillance system be well defined, because these products have varying cost/billing structures that may include an annual fee.)

## RESULTS

### Single-event alerts

The initial implementation of the software involved defining the single-event alerts that would guide the surveillance activities of each ICP according to his or her areas of responsibility. The system allows for event alerts based on organism, clinical unit or service, type of specimen, or antibiotic susceptibility criteria established by the user. When a single event is identified, an e-mail notification is generated and sent to the appropriate practitioner (Fig 1). The event alerts can be easily set up and turned on and off; they continue

There were 23 Single Event alerts since your last session.

Event Name (click to view Single Event log)	Alert Date	Patient Viewed	Remove
<a href="#">Shock Trauma All Bloods</a> [Details]	02/16/2004	No	[Remove]
<a href="#">Shock Trauma All Bloods</a> [Details]	02/16/2004	No	[Remove]
<a href="#">Shock Trauma All Bloods</a> [Details]	02/16/2004	No	[Remove]
<a href="#">SICU MRSA List</a> [Details]	02/16/2004	No	[Remove]
<a href="#">CTICU All Blood Cultures All Service</a> [Details]	02/15/2004	No	[Remove]
<a href="#">CTICU All Blood Cultures All Service</a> [Details]	02/15/2004	No	[Remove]
<a href="#">Shock Trauma All Bloods</a> [Details]	02/15/2004	No	[Remove]
<a href="#">Shock Trauma All Bloods</a> [Details]	02/15/2004	No	[Remove]
<a href="#">Shock Trauma All Bloods</a> [Details]	02/15/2004	No	[Remove]
<a href="#">Shock Trauma All Bloods</a> [Details]	02/15/2004	No	[Remove]
<a href="#">Shock Trauma All Bloods</a> [Details]	02/15/2004	No	[Remove]
<a href="#">Shock Trauma All Bloods</a> [Details]	02/15/2004	No	[Remove]
<a href="#">SICU Bloods</a> [Details]	02/15/2004	No	[Remove]

Fig 1. Listing of event alerts for the ICP based on areas of responsibility.

- Single event alert components chosen
  - Any organism
  - No drug resistance specified
  - Specimen source – blood
  - Unit – Pediatric Intensive Care Unit
  - Any service
  - Required hours of hospitalization – 24
  - Incubation – 48 hours
  - Report all events for a patient

Fig 2. Case finding for BSI surveillance.

to compile information for later access even when turned off. In addition, the alerts can be transferred to other practitioners by the originator.

Figure 2 illustrates the criteria used to set up an event alert for bloodstream infection (BSI) surveillance in a pediatric intensive care unit (PICU). This alert provides information to the ICP on all positive blood cultures obtained from patients in the PICU. The alert limits the information to cultures obtained 24 hours or more after admission, defines a 48-hour incubation period to aid in capturing episodes of BSI occurring in that time interval after a patient is discharged from the unit, and reports all blood cultures for a single patient. Each alert allows the ICP to view the patient movement within the medical center, along with the history of microbiology testing. Viewing all of the culture data facilitates identification of other culture sites that may be

positive for the same organism (eg, a catheter tip culture providing evidence of a catheter-associated BSI).

Event alerts also were set up to serve as an adjunct case-finding method for surgical site infection (SSI), pneumonia, and ventriculitis surveillance. An alert was established for all positive wound cultures from surgical services targeted for SSI surveillance. For ventilator-associated pneumonia surveillance, an alert to identify all bronchoalveolar cultures obtained from any patient in the ICU was established. To facilitate ventriculitis surveillance, an alert for all positive cerebrospinal cultures was developed.

Another surveillance objective was to detect sentinel organisms to ensure prompt isolation of a patient in an effort to reduce the potential for cross-transmission to other patients and, in some cases, health care workers and visitors. Figure 3 shows an example of an alert for detection of all cases of laboratory-confirmed influenza. This alert is organism-specific and defines 0 hours of hospitalization as a criterion, to ensure that all cases, both community and hospital-acquired, are captured. Sentinel event alerts for antibiotic-resistant organisms, such as methicillin-resistant *Staphylococcus aureus* (MRSA), were established to detect all cases occurring in pediatric and obstetric units (Fig 4), as well as all cases occurring among inpatients at the medical center. Note that the alert is organism-specific but specifies drug resistance to methicillin, nafcillin, or oxacillin.

Other alerts were established with implementation of the software to ensure detection of sentinel organisms that must be reported to the Maryland DHMH. These organisms and specimen sources were defined by the DHMH criteria.

- Single event alert components chosen
  - Organism group – Influenza
    - A, B, antigen, culture
  - No drug resistance
  - Any specimen source
  - Any unit
  - Any service
  - 0 hours of hospitalization
  - Report a patient only once

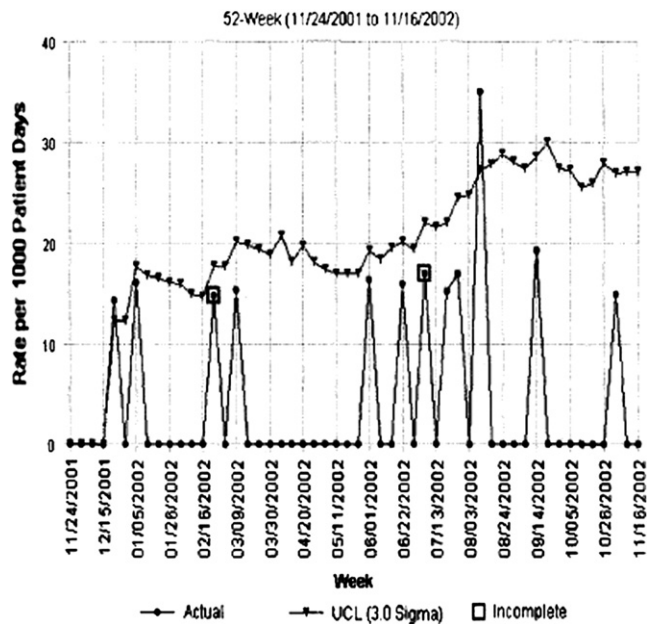
**Fig 3.** Detection of all cases of laboratory-confirmed influenza.

- Single Event Alert components chosen
  - Organism – *S. aureus*
  - Drug resistance – methicillin, nafcillin, or oxacillin
  - Any source
  - Peds ED, Peds units, OB units
  - Any service
  - No required hours
  - All events for a patient

**Fig 4.** Case finding for MRSA in women and children.

## Control charts

In addition to single-event alerts, initial implementation of the software included the setup of process control chart analyses. These analyses use criteria similar to those used for single events, with patient-days obtained from the ADT database. For each specified time period (eg, weekly, monthly), the sum of the number of patients who met the control chart definition criteria is divided by the sum of the number of patients at risk for each day during that time period and then multiplied by 1000 to be reported “per 1000 patient-days.” The center line is calculated to provide a baseline rate for each period as  $CL = n/p$ , where  $n$  is the cumulative number of events within a period and  $p$  is the total number of patient-days within the same specified period. The software uses 52 weeks of data to provide a stable baseline, from which a standard deviation (sigma) is calculated. The alert level (upper



**Fig 5.** *C. difficile* in the medical intensive care unit.

control limit) for each control chart is established by the originator. If the rate exceeds the assigned sigma level (generally 2 or 3 sigma), then an e-mail notification is generated. These analyses facilitate the detection of potential clusters of related infections that warrant epidemiologic investigation. Figure 5 illustrates a control chart designed to monitor the occurrence of *Clostridium difficile* in the medical intensive care unit. The chart fired above the 3-sigma level, with 4 patients identified in the alert. An investigation revealed both spatial and temporal association among the cases, prompting the initiation of heightened infection control measures.

Wright et al<sup>3</sup> retrospectively reviewed 13 months of data comparing the automated surveillance application with standard infection control practices. They concluded that the automated surveillance system with user-defined control charts for cluster identification was more sensitive than routine infection control surveillance and operated with high specificity and positive predictive value in a time-efficient manner.

## DISCUSSION

A shift in process from a manual review of microbiology reports to an automated surveillance methodology has had many advantages and few limitations (Table 1). Our experience with an automated surveillance system has been extremely positive, resulting in improved resource utilization and timely reporting of data to clinicians and external agencies. The system has eliminated the need for manual review of the microbiology report, releasing approximately 10 weeks

**Table I.** Advantages and disadvantages of automated surveillance

Advantages	Disadvantages
<ul style="list-style-type: none"> <li>● Prospective surveillance can be customized to meet the institution's defined surveillance plan.</li> <li>● Eliminates the need for manual review of microbiology reports.</li> <li>● Usability comparable to that of many Windows-based programs.</li> <li>● Process control chart analyses available.</li> <li>● Electronic notifications by e-mail allow for immediate action.</li> </ul>	<ul style="list-style-type: none"> <li>● Not able to conduct retrospective surveillance before system startup.</li> <li>● Data displayed in the format and level of usability as defined by vendor.</li> <li>● Query results delayed for 24 hours.</li> </ul>

of ICP labor annually. The flexibility of Internet-based software allows the ICPs to perform surveillance activities outside of the office setting. The use of wireless notebooks has increased the ICPs' visibility on the clinical units, allowing them to audit infection control practices, participate in interdisciplinary rounds, and provide education to all levels of staff. The event alerts that have been developed for DHMH reporting can be viewed and acted on by administrative support staff, relieving the ICPs of this duty. Electronic notification through e-mail ensures prompt receipt of pertinent event alerts, promoting rapid intervention when warranted. The ability to customize alerts based on the surveillance priorities of the individual institution and the responsibilities of individual practitioners promotes autonomy and prevents redundancy of effort. The process control analyses performed by the software have been found to be more sensitive than routine infection control surveillance, thus allowing for more rapid detection of potential outbreaks.

Several factors are perceived as potential limitations of the automated surveillance system implemented at our medical center. The vendor was unable to backload historical microbiology data, thereby limiting retrospective surveillance with the system to the startup date of the software. In addition, the software does not function in real time, resulting in a delay of 24 hours for single-event alerts and process control chart analyses. This has required the information technology department to develop backup data queries for historical trending purposes and for the detection of sentinel organisms. Finally, the data only display in a format and level of usability defined by the vendor.

Health care-associated infections are responsible for nearly 90,000 deaths and \$5 billion in excess costs annually.<sup>4</sup> Preventing these infections, as well as controlling antibiotic-resistant organisms, have been targeted by organizations promoting patient safety (eg, Institute for Healthcare Improvement), regulatory agencies (eg, Joint Commission for Accreditation of Healthcare Organizations), and legislators responding to the outcry from patient advocacy groups. These initiatives constitute the mission of ICPs worldwide. Although surveillance is an essential part of prevention and control, all too often it consumes too much of an infection control staff's time and energy, limiting the time available for educational and performance improvement efforts. Automated surveillance systems have the ability to streamline the process by facilitating efficient review of relevant data and promoting rapid identification of sentinel events and detection of outbreaks.

#### References

1. Wright MO. Using computer technology to collect and manage data. In: Arias K, editor. APIC infection control toolkit series: Surveillance programs in healthcare facilities. Washington, DC: Association for Professionals in Infection Control and Epidemiology; 2003.
2. Gaynes R, Friedman C, Copeland TA, Thiele GH. Methodology to evaluate a computer-based system for surveillance of hospital-acquired infections. *Am J Infect Control* 1990;18:40-6.
3. Wright MO, Perencevich EN, Novak C, Hebden JN, Standiford HC, Harris AD. Preliminary assessment of an automated surveillance system for infection control. *Infect Control Hosp Epidemiol* 2004; 25:325-32.
4. Adams K, Corrigan JM, editors. Officials should target 20 key areas to transform the health care system [press release]. Washington, DC: Institute of Medicine; 2003.