Chapter 4

Surveillance for Healthcare Infections

Kathryn N. Suh and Terrie B. Lee

Key Points
Surveillance: • is a key component of infection prevention activities • includes the systematic collection and analysis of data, and dissemination of results to those who can effect change • is most useful if data are provided in a timely manner to those who need to know so they can improve the quality of care provided to patients • must be appropriate for the population(s) at risk • should be able to detect changes in patterns of healthcare-associated infections and/or infection prevention and control processes

What is Surveillance?

Surveillance, in the public health context, is the "ongoing, systematic collection, analysis, interpretation, and dissemination of data regarding a health-related event for use in public health action to reduce morbidity and mortality and to improve health".[1] One of the key elements of surveillance is that the process must be systematic. Furthermore, there is little gain to performing surveillance if the information and results obtained from it will not be used. The specific goals of surveillance may vary somewhat depending on who is conducting it and the population under study, and may include any or all of the following: establishing baseline or endemic rates of disease; identification of disease outbreaks or changes in disease trends; determination of risk factors for or the natural history of specific diseases; measurement of compliance with established standards; and assessment of the effect(s) of practice changes, new interventions, or new technology. Surveillance in an infection prevention and public health context also aids in the detection of communicable diseases of public health importance that should be reported to health authorities to prevent spread (e.g., tuberculosis, viral haemorrhagic fevers, sexually transmitted infections), provides the foundation for immediate preventive actions (e.g., in outbreaks of disease), and directs public health policy. Ultimately, surveillance should generate data that can be applied in some manner to improve care.

An early example of surveillance is John Snow's investigation of the 1854 cholera outbreak in London. With the "germ theory" of disease still to be postulated, he used rudimentary epidemiologic and statistical methods to identify water as the source of the outbreak. He recommended removing the Broad Street pump handle, preventing further consumption of contaminated water and stopping the outbreak, although the outbreak was already waning by this time. Surveillance was identified to be a necessary public health practice only in the 1950s[2] and the term "disease surveillance" was introduced. Outbreaks of staphylococcal infection in hospitals in the United States around the same time led to the first recommendations for surveillance programs in hospitals.[3] Haley's sentinel Study of the Efficacy of Nosocomial Infection Control (SENIC)[4] provided the earliest evidence of the impact of surveillance on reducing healthcare-associated infection (HAI) rates.

In healthcare settings, surveillance for HAIs is a fundamental activity of infection prevention services. Without knowledge of existing (baseline) data, 1) it is difficult to know if improvement may be needed; 2) outbreaks may also be missed, and 3) the effect of practice changes may not be appreciated. Regional, national and international infection control surveillance collaborations such as the International Nosocomial Infection Control Consortium[5] (INICC: global, including Latin America, Asia, Africa, Europe; http://www.inicc.org), the National Healthcare Safety Network[6] (NHSN, United States; www. cdc.gov/nhsn/), Canadian Nosocomial Infection Surveillance Program (CNISP, Canada; http://www.phac-aspc.gc.ca/nois-sinp/survprog-eng.php), and the European Centre for Disease Prevention and Control (ECDC, Europe; http://ecdc.europa.eu/en/healthtopics/Healthcare-associated_infections), among others, generate surveillance data that provide valuable information regarding overall geographic trends. However, due to differences in surveillance methods or definitions, these results may not serve as accurate references (benchmarks) for comparison with individual facility or program rates.

Establishing a Surveillance Program

A good surveillance program will include a written plan that outlines the goals and objectives of the program, and should be based on a framework that includes several well-defined practices.[6] A written plan also allows

for strategic allocation of resources to enable effective and meaningful surveillance, decrease HAI rates, and improve patient safety. Surveillance programs should be evaluated periodically to ensure that they are effectively meeting the needs of the facility.[1,7]

Questions to consider when establishing a surveillance program in any healthcare organisation may include the following:

1. Is it necessary to survey the entire health care facility or only focus on high-risk (targeted) patient groups / procedures or commonly performed procedures?
2. What data currently exist that can help to direct surveillance activities – are there historical data, or is there need to obtain some baseline data first?
3. Have rates increased in certain groups / procedures/interventions? What are the most important infection prevention and control processes associated with this rate, and should they also be measured?
4. Are there emerging infection threats that need to be monitored?
5. How will case definitions be (developed and) applied?
6. Should continuous surveillance or point prevalence surveys be used?
7. How will the data be collected, stored, retrieved, analysed, summarized, and interpreted?
8. How will results to clinicians be provided in a timely manner?
9. How will the information be used to continue to lower infection rates?

Steps for Planning and Implementing Surveillance

The following framework is useful in planning and implementing a sound surveillance program.[7] These steps can be applied in different healthcare settings, as the principles of a good surveillance program are not setting-dependent.

1. Assess the population

Prior to starting a surveillance program, it is important to define the population served by the facility or the program. Processes and outcomes to be measured will depend on the patient population, the most common diagnoses, the most common procedures performed, and an understanding of whether there are increased infection risks to patients based on either the patient demographics or the procedures provided. This information will help to define what surveillance activities (and therefore what process and outcome measures) should be priorities.

2. Select the process or outcome for surveillance

Surveillance can measure either processes or outcomes. **Processes** are activities that are typically performed by a healthcare provider at some point during the course of patient care. Examples of measurable processes include hand hygiene, administration of pre-operative antibiotic prophylaxis, healthcare worker immunization, or device use; each of these is an action that is performed on or for a patient. Self-care activities performed by patients, such as pre-operative antiseptic bathing, can also be considered as processes. **Outcomes**, in contrast, refer to the results of care; examples include HAIs, pressure ulcers, falls, and deaths.

Surveillance targets should be relevant to the facility or program and the patient population it serves. Factors that may influence the selection of surveillance targets include the frequency of the outcome, associated morbidity and mortality, direct and indirect healthcare costs of the outcome, and the ability to influence change

(i.e. improve outcomes). Epidemiologically important pathogens, such as methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant enterococci (VRE), extended-spectrum beta-lactamase (ESBL) producing gram-negative bacilli, and *Clostridium difficile*, for example, are often included in surveillance programs. In some regions or countries, mandatory reporting of some HAI rates is also required. For example, acute care hospitals in the U.S. are required to report data on several outcomes such as central line-associated bloodstream infections (CLABSIs) and catheter-associated urinary tract infections (CAUTIs), as well as influenza vaccinations (a process measure). There are also requirements for outcome or process reporting from ambulatory surgery centres, cancer hospitals, long-term acute care facilities, inpatient psychiatric facilities, inpatient rehabilitation hospitals, and outpatient dialysis centres. This required reporting of data leads to predetermined areas of focus for a surveillance program, and may not leave time enough for implementation of prevention measures if the program is not sufficiently funded.

3. Use surveillance definitions

Healthcare associated infections are "infections occurring in a patient during the process of care in a hospital or other health-care facility which was not present or incubating at the time of admission. This includes infections acquired in the health-care facility but appearing after discharge, and also occupational infections among health-care workers of the facility".[8] A cut-off point of disease onset 48 hours or more after admission is typically used to distinguish between HAI and community-associated infections, although a surveillance system may identify more precise time-frames for HAIs, including parameters for including post-discharge cases.'

Case definitions used for HAI surveillance should be consistently applied. They should be written and, where possible, validated (i.e. tested to ensure that they measure what was intended); this ensures that there is consistency and accuracy of surveillance results, and allows comparison of rates over time within a facility (or with other organizations) provided surveillance methods and definitions are the same. The NHSN in the United States (2016 NHSN case definitions are available at http://www.cdc.gov/nhsn/PDFs/pscManual/17pscNosInfDef_current.pdf; note definitions are updated on a regular basis and may change from those in this document), the ECDC,[9] and the INICC[5] provide examples of standardized surveillance definitions for acute care settings. Case definitions should indicate time frames for classifying infections as HAIs, clearly define inclusion and exclusion criteria, and may incorporate both clinical and laboratory criteria, It is important to recognize that cases of specific HAIs identified using surveillance definitions (meant to be applied to an aggregate population) may not always be in agreement with clinical diagnoses (meant to be applied to individual patients). Case definitions may not be appropriate for all settings and can be modified if needed, but modifications should be clearly documented, as these will affect the ability to compare surveillance results within and between facilities. Sometimes definitions must be developed *de novo*, for example when new diseases emerge. Separate definitions may also exist for different settings; for example, some long-term care HAI definitions may be less dependent on laboratory testing,[10] and the Association for Professionals in Infection Control and Epidemiology, Inc. (APIC) has developed HAI definitions for use in home health and hospice settings.[11]

4. Collect surveillance data

Surveillance activities should be supervised by a professionally trained infection prevention and control expert, but most will also rely on the assistance of others to complete the data collection process. This includes assistance from nursing staff in identification of patients with signs or symptoms of infection, counting or

documentation of device days (for example, for central venous catheters or indwelling catheters), or in documentation and collection of surgical risk information such as wound classification, and other risk factors. Respiratory care staff might assist in collecting data related to ventilator care for patients. Laboratory staff provide essential information related to microbiology and other laboratory tests. An administrative office may provide needed statistics on numbers of patients, patient days, and information on discharges. It is critical that any individuals involved in the collection of surveillance data receive training that is particular to their role in surveillance. Not only should everyone be educated, but this education should be validated by checking their accuracy in test cases, and re-training provided at routine intervals, for example, annually.

Surveillance data may be gathered from several different sources. Both numerator (number of infections during the surveillance period) and denominator (number of patients at risk of the infection during the surveillance period) data are required for most surveillance activities. Data sources that can provide useful information for HAI surveillance may already exist within a facility; examples include laboratories, medical records, and patient admission data. Identification of HAIs can be accomplished through either active or passive surveillance, or a combination of both. Whichever method is used, it is important to use the same definitions and data collection method over time so that any change in the rates is not due to changes in methodology.

Hospital-wide ("whole-house") surveillance of all admitted patients permits determination of an overall facility HAI rate, i.e. overall percentage of patients with an HAI during the surveillance period. In general, this practice is discouraged for several reasons. Apart from being extremely labour intensive, overall HAI rates may not accurately convey the relative importance of certain HAIs compared with others, and does not allow for risk stratification (see below) or adjustment. Furthermore, an overall rate may underestimate true HAI rates, as patients with multiple infections are counted only once. However, hospital-wide surveillance may be reasonable in two instances. If historical data are not available, a limited period of surveillance could lend enough information to identify where focused surveillance would be useful. Prevalence, rather than incidence rates might also be helpful in this situation. Overall surveillance may also be useful if a facility is so small (e.g., less than 100 beds) that the numbers of procedures of a specific type are small, and it is difficult to analyse the data in any meaningful way. In this situation, *incidence* or *prevalence data* analysis might be useful. The overall limitation in either situation is still the inability to compare these HAI rates to HAI rates reported by any other facility, regardless of their similarity, or even in comparison to the organization's own rates over time.

Targeted surveillance, either for specific HAIs, e.g., CLABSIs; surgical site infections, [SSIs] or within specified populations (e.g., intensive care units) is therefore preferred. Targeted surveillance allows infection prevention resources to be used most effectively by focusing on high-risk outcomes or populations.

Case finding can be performed in two ways: active and passive. Active surveillance involves having trained individuals such as infection control professionals actively looking for cases of HAI. This may involve regular (e.g., daily) visits to patient wards/care units to assess patients at risk of HAIs and/or review of their medical records. Information in the patient's chart that might indicate that a patient has an HAI includes vital signs (fever), or antibiotic use on a medication administration record. While active surveillance is the most sensitive method for detecting HAIs during admission, it is expensive because it requires trained staff and takes time; many patients or charts may need to be assessed to find few infections.

Passive surveillance relies on others (e.g., physicians, nurses, or the microbiology laboratory) who are not pri-

marily responsible for surveillance activities to report HAIs. Reported cases may not meet standardized criteria for HAIs, and true cases may be missed entirely. Identification of outbreaks may be delayed, or missed altogether, as data collection is not systematic. As a primary method of surveillance, passive surveillance is not desirable.[12] In one study, passive reporting of SSIs by physicians missed over one third of SSI cases identified by trained infection control professionals.[13]

Laboratory reports may be helpful for triggering suspicion of an HAI, initiating a more detailed chart review. Reliance on laboratory results alone (in the absence of clinical evidence) may lead to misclassification, as positive laboratory reports do not always indicate infection, and negative ones do not always indicate absence of infection. The usefulness of laboratory testing is severely reduced if physicians do not send specimens for testing. *However, for specific organisms of epidemiologic and infection control importance (e.g., MRSA, tuberculosis), passive reporting by the laboratory is relatively simple and inexpensive, and in computerized laboratories, can be automated.* Laboratory reports can be used to identify trends of specific microorganisms in different wards over time, and facilitate the infection prevention team's strategy for preventive actions. In facilities in developing countries, the lack of microbiology laboratories can be a critical problem.

No method of case finding is perfect, and each has its limitations. The relative benefits of different methods may vary among facilities, and may be determined in part by what data sources already exist. In general, case finding using a combination of active and passive surveillance with electronic alerts (from the laboratory, for example) is commonly used and can improve detection of HAI cases compared with using only a single method.

A data collection tool should be developed for recording data on HAI cases. This can be a hard copy (paper) form or, ideally, computer based. The information recorded should include *basic data such as patient demographics and date of admission or procedure, for example*, *but should also include data elements that are relevant to the HAI under surveillance, and can be updated as new information becomes available*. The data collection tool should be reviewed to ensure that data are complete, and audited periodically to ensure good data quality.

5. Analyse and interpret the data

Surveillance data are analysed periodically to produce results, usually calculated as rates (see next section). The frequency of reporting is often determined by the size of the denominator; rates based on few observations or a short at-risk period may be misleading and highly variable. However, the reporting frequency should take into consideration the need to act on results in a timely manner. Reporting may occur at the end of every month or quarter, for example, but reporting increased rates of a specific HAI that occurred in the remote past will not be meaningful. Prevalence data collected using point prevalence surveys are usually analysed immediately at the end of the survey to establish a rate that reflects that survey period.

Infection rates will vary according to the definition used, and comparisons should only be made if the same set of definitions is used and applied in exactly the same manner. Hence, it is often more meaningful to use surveillance data from one's own institution to measure trends over time, either to alert staff of increasing problems or to monitor the effectiveness of interventions.

The threshold rate for a specific HAI may be set by previous surveys, followed by discussions with clinicians (e.g., surgical teams) about what target they believe they can achieve. Alternatively, a threshold may be

based on published literature. Published rates largely come from high resource health care systems or collaboratives (e.g., NHSN, CNISP) and may not be appropriate for others. Rates for comparison in lower or mixed resource health care facilities are available from the INICC.[14,15] In some developed countries, a target of zero has been established, especially for HAIs that are known to be avoidable with implementation of appropriate prevention methods. This has been a controversial topic, particularly in countries or organizations that are in beginning stages of infection prevention and control, or in areas where resources for prevention methods are limited.

Rates for a current surveillance period may appear to be higher than the accepted threshold; however, this may be because the sample size does not include every patient (i.e., full population). If every patient is surveyed, the rate reflects a population. If not all patients are evaluated during a survey period (this is most common because patients move beds, are transferred, discharged, or die before being surveyed), then a statistic that reflects the reliability of this estimate of the true rate can be calculated. The 95% confidence interval (CI) provides boundaries around the sample rate. If the 95% CI includes (or is below) the threshold rate, then the rate is considered to be within acceptable limits. Confidence intervals can be calculated from the numerator and the denominator. Downloadable software is available to help with calculations (see Additional Resources at the end of the chapter).

6. Apply risk stratification

Risk stratification is a method of controlling for differences in the underlying risk of infection. This is done by subdividing the surveillance population into groups based on similar characteristics that are known to be associated with different risks of a given HAI. Risk stratification by birthweight is a common example, used when analysing neonatal outcomes such as CLABSIs, for which birthweight is known to influence the risk of developing a CLABSI. Risk stratification has historically been used for reporting SSI rates, using characteristics such as the surgical wound class (i.e. classes I to IV: clean, clean-contaminated, contaminated, dirty) or the NHSN (NNIS) risk index.[16] The greater the wound contamination or the higher the risk index, the higher the expected SSI rate; thus, providing an overall SSI rate without risk stratification may provide misleading and inaccurate results. Stratification therefore allows more meaningful comparisons of rates to be made, provided that the denominator (population) in each stratum is large enough to provide statistically valid results.

7. Report and use surveillance information

Surveillance reports should include information outlining the rationale for surveillance, if not already understood; the surveillance period; determination of incidence versus prevalence rates; thresholds for comparison; interpretation of any results; and any infection prevention and control actions required based on the results.

Surveillance results must be provided regularly, in a timely manner, and in a useful and understandable format to the front-line clinical staff in order to help them choose actions or improve processes to reduce infection rates. Rates should also be provided to administrators, who can ensure that sufficient resources can be provided for implementing practice changes. Basic descriptive data should be provided about the total number of cases (the numerator), the total number of patients or device-days (the denominator) for each rate, as well as previous rates to demonstrate any significant changes. Graphs and other pictorial representations of

HAI rates are often easier to understand by front-line staff and other users, and can more readily display thresholds and confidence intervals. One helpful reference about how to effectively present infection control data is available online at www.webbertraining.com/files/library/docs/19.pdf.

Evaluating the Surveillance Program

Surveillance programs should be periodically evaluated to ensure that they are providing relevant information in an efficient, effective way. If the surveillance activities are not meeting the program's goals or are not contributing to improving patient safety and reducing HAI rates, they need to be re-evaluated.

Attributes of a surveillance program that should be assessed include the following: the simplicity of the system; its ability to adapt to changing circumstances; the quality of the surveillance data; acceptance of the program by front-line staff; the ability to detect HAI cases (sensitivity); representativeness of the population under study; timeliness of surveillance activities; and the reliability of the system (i.e. ability to withstand unanticipated challenges, and to provide data as required).[1] Changes in the surveillance program should then be made based on the program evaluation results. Periodic evaluation of the program can also define whether existing human resources are adequate to accomplish the program's goals, specifically whether additional resources are required.

Important Surveillance Methodology Considerations

Whenever measurements are taken, there will inevitably be error. Errors may be random or systematic. Random errors can never be eliminated, only reduced by increasing the sample size. This may be impossible in surveys on a small number of patients.

Systematic errors can be reduced by using standardized methods. This means the application of valid definitions is reliably performed in the same way every time. Reliability and validity of HAI definitions are two important concepts of surveillance. The target (Figure 4.1) illustrates both high validity and reliability – the arrows that hit the true mark illustrate validity, and arrows that hit the same spot on the target each time illustrate repeatability or reliability. If the arrows hit to the side of the target each time, then the results would be reliable but not valid.

Figure 4.1. High reliability (arrows in the same spot) and validity (arrows hit the target).

Basic Statistics for Surveillance: Calculating Rates

Rates, Ratios and Proportions

Surveillance data are used to determine HAI rates. A **rate** is the occurrence of an event in a specific population during a defined time period. Calculation of rates requires that the event (the numerator, e.g., a specific HAI) can be identified, and that the population at risk of acquiring or developing the HAI (the denominator) can similarly be enumerated.

Cases of a specific HAI (the numerator) may be identified by using a variety of methods (see next section), but

a standardized, validated case definition should be used whenever possible. The population at risk (the denominator) should in general include all individuals who could have developed the outcome of interest. For example, in calculating an SSI rate after abdominal hysterectomy, only women who have had an abdominal hysterectomy (who therefore could have developed an SSI related to this procedure) should be included. Similarly, if a patient has already developed an outcome, s/he is not at risk of becoming a new case and should not be included in the denominator during the period of study (e.g., patients known to already have MRSA colonization should not be included in the denominator when calculating MRSA colonization rates). For some outcomes, the risk may be influenced by the duration of exposure to a specific risk factor and therefore a determination of the cumulative exposure may be more appropriate. For example, patients cannot develop ventilator-associated events (VAE) without being ventilated; the risk of a VAE increases with duration of ventilation; therefore, an appropriate denominator would indicate the duration of exposure to a ventilator, expressed as ventilator-days. *Rates can then be reported as the rate of VAEs per 1000 ventilator-days, and interpreted as the risk of acquiring a VAE.*

A **ratio** is a fraction, obtained by dividing one quantity (the numerator) by a second quantity (the denominator); the numerator may or may not be included in the denominator. A **proportion** is a ratio in which the numerator must be included in the denominator. The **mean** is the mathematical average of a set of values. The **median** is the mid-point of a set of values when the set is arranged in order from lowest to highest.

The **device utilization ratio** is the number of device-days per number of patient-days in a given period. This is a measure of the total patient-days in which a high-risk device was used, and can be used as a marker for risk of infection.

$$\text{Urinary catheter utilization ratio} = \frac{\text{Total number of urinary catheter-days}}{\text{Total number of patient-days}}$$

$$\text{Central catheter utilization ratio} = \frac{\text{Total number of central catheter-days}}{\text{Total number of patient-days}}$$

Incidence

The incidence of an HAI is a specific rate that represents the occurrence (number) of new cases of a disease (e.g., a specific HAI) occurring in a defined patient population during a defined period. All individuals in the population being surveyed must be at risk of developing the outcome. To calculate incidence, the number of patients at risk of the specific HAI during the surveillance period forms the denominator:

$$\frac{\text{Number of patients diagnosed with new specific HAI during the surveillance period}}{\text{Number of patients at risk of the specific HAI during the surveillance period}} \times 100$$

Strictly speaking, however, we often perform continuous surveillance and measure the **cumulative incidence** of cases in the population at risk. Two assumptions are made when reporting cumulative incidence: a) the population at risk (the denominator) should include all patients who are at risk of developing the outcome at the beginning of the surveillance period; and b) every individual in the population at risk is followed for the same duration (Figure 4.2).

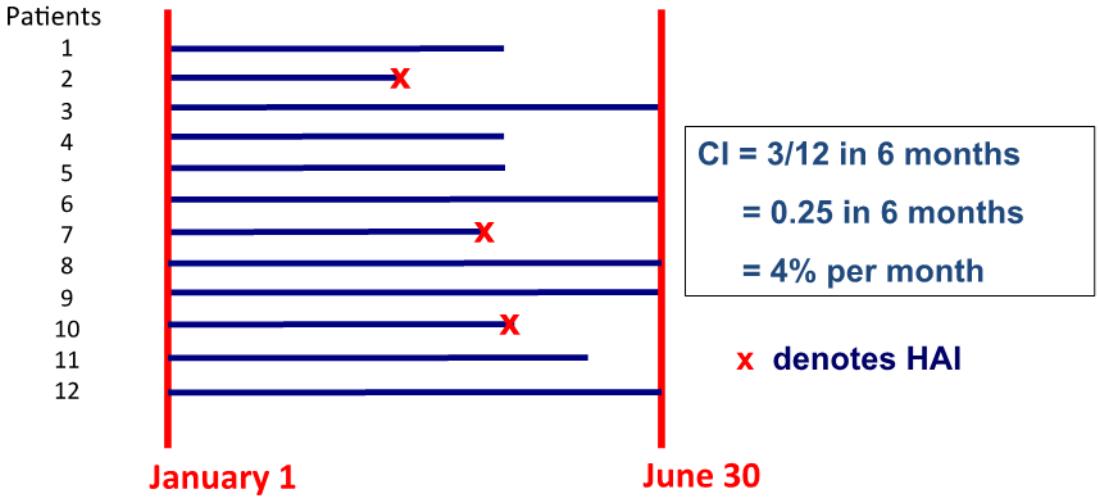

Figure 4.2: Cumulative incidence. Twelve patients are surveyed for the development of a specific HAI. Three patients develop an HAI (denoted by the "x"). The calculation of the cumulative incidence (4% per month) is shown in the box. Cumulative incidence assumes that the entire population at risk is included from the beginning of the surveillance period and is followed for the same duration.

If patients are followed for the occurrence of an HAI but the time of follow-up varies for each patient, a more precise measure of incidence called **incidence density** is used. To calculate the incidence density, the denominator would be the cumulative duration at risk (of developing the outcome) of all patients, expressed as person-time. For example, the unit of risk may be one day in hospital; each patient may have different lengths of stay in hospital (i.e., hospital-days).

Incidence density can be expressed as:

$$\frac{\text{Number of new specific HAI during the surveillance period}}{\text{Sum of person-time of susceptible patients at risk during the surveillance period}} \times 1000$$

As shown in Figure 4.3, six patients are followed up for varying lengths of time; in total, the cumulative follow up time is 35 days. If two patients develop the HAI of interest during follow up, the incidence density is 57 cases per 1000 patient days. Another situation in which incidence density is useful is for device-related infections (e.g., CLABSIs). The risk of developing a CLABSI increases with increasing exposure to the risk factor (catheter). For patients surveyed for CLABIs, the denominator that best represents the at-risk exposure would be the cumulative duration of exposure to central lines among all patients being surveyed, measured as catheter-days, where one catheter day is defined as one day with at least one central line. The CLABSI rate would be:

$$\frac{\text{Number of CLABSIs during the surveillance period}}{\text{Sum of central line days during the surveillance period}} \times 1000$$

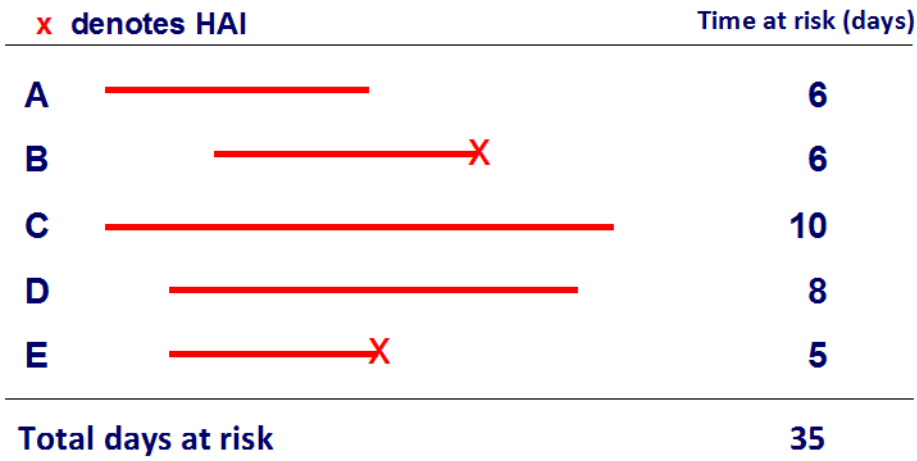

Figure 4.3. Incidence density. Incidence density takes into account varying periods of follow up until the outcome. Five patients A, B, C, D and E are followed for varying lengths of time. In total, there are 2 HAIs in 35 patient days of follow up. The incidence density would therefore be 2 HAIs per 35 patient days, or 0.57 per 1000 patient days.

In this example, central line days can only be determined among patients who have central lines. The rate obtained would be expressed as a number per 1000 central line days. Similarly, CAUTI rates can be calculated using the following, to give the rate of CAUTIs per 1000 urinary catheter days:

$$\frac{\text{Number of CAUTIs during the surveillance period}}{\text{Sum of urinary catheter-days during the surveillance period}} \times 1000$$

On occasion, there may be problems with an inability to accurately determine denominators for the surveillance period. This would most commonly occur with at-risk denominators used for calculating incidence densities, e.g., for device related infections. One method that can be used to overcome this is to average available denominator data to estimate missing values.[17] An alternate approach is to use sampling, the regular but less frequent collection of denominator data, for example on a given day every week.[18,19] There is a small degree of error when sampling is performed, the effect of which increases with smaller denominators.[18] While these approaches have not been widely used or evaluated, they may be options in facilities where resources do not permit ongoing continuous surveillance.

A very specific form of an incidence rate is an **attack rate**. An attack rate is similar to an incidence rate but is usually used to describe the incidence of disease related to a common exposure (e.g., outbreak), and expressed as a proportion (percentage). It is calculated using the same basic method as a regular incidence rate.

Prevalence

The prevalence of an HAI is the proportion of patients who have active (new and previously diagnosed) HAI in a defined patient population during the surveillance period. These may be new cases, or cases that developed before the survey.

$$\text{Prevalence (\%):} \quad \frac{\text{Number of new and existing cases of specific HAI during the specified survey period}}{\text{Total number of patients surveyed for specific HAI during the specified survey period}} \times 100$$

In general, prevalence increases the longer the duration of the disease. Prevalence can be assessed at one single point in time (point prevalence) or over a defined time period (period prevalence). Since prevalence rates include new and existing infections, these cannot be compared with incidence rates, which include only new infections.

Figure 4.4 depicts a short prevalence survey of seven days (period prevalence). Six patients were surveyed, and two had an active infection: Patient E developed a new infection during the surveillance period and Patient F had an existing infection. Therefore, the number of infections (numerator) would be two out of six (denominator) patients, giving a prevalence of 33%. Patient C acquired an infection that is not included because it appeared after the last day of the survey.

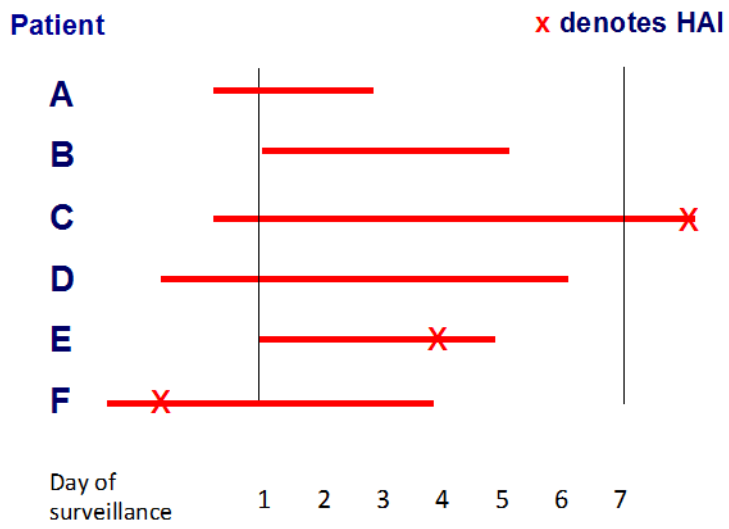

Figure 4.4. Prevalence. Six patients, A, B, C, D, E and F are assessed during a 7-day period prevalence study. Two patients, E and F, had an HAI during the surveillance period; patient E developed an HAI during the surveillance period, while F had an existing HAI. The prevalence of HAI would then be 2 out of 6 patients, or 33%. Patient C is not included in the numerator since the HAI only developed after the surveillance period had ended.

Surveillance Methods in Infection Prevention and Control

Continuous Surveillance versus Prevalence Surveys

Continuous surveillance is typically undertaken prospectively; it is the best way to establish trends and distribution of disease incidence. Intrinsic risk factors and proxy measures should also be examined to ensure that rates of HAI have not changed because of these factors rather than clinical practice.[20] Examples of in-

trinsic risk factors include age, gender, blood loss, smoking behaviour, immune status, or underlying diseases/conditions that may increase the risk of infection. Simple measures of age and average length of stay (as a measure of severity of illness) may be useful proxy risk factors. Extrinsic risk factors are easier to control; examples include hand hygiene, pre-operative length of stay, duration of surgical procedures, surgical teams that include trainees, and pre-operative skin preparation. Sometimes both intrinsic and extrinsic risk factors can change HAI rates (e.g., increased colonization with community-associated MRSA in patients combined with poor hand hygiene by healthcare workers). Relevant risk factors should be measured to identify any significant changes; these factors may explain a changed HAI rate and require refocusing of infection prevention efforts.

Prevalence surveys are an alternative to continuous surveillance, particularly if resources do not permit continuous surveillance. Performed on a single day or week, they can show the magnitude of HAI within a health care facility or region, highlight problems requiring more investigation, and identify changing patterns of HAIs. Point prevalence studies have shown that the prevalence of HAIs is approximately 5%-16% depending on the health care setting.[7,21-23] Prevalence surveys can be used to target areas or services where infection rates are suspected to be high, or to focus on measuring processes (e.g., hand hygiene, antibiotic prophylaxis). Repeated prevalence surveys can also demonstrate changes in rates. Significant potential disadvantages of prevalence surveys include the possibility of missing cyclical or seasonal variations in rates, and the inability to detect outbreaks if the survey does not coincide with the outbreak.

Post-discharge Surveillance

Some HAIs will become apparent only after discharge from hospital. This is especially true for surgical site infections (SSIs), and particularly in countries where short post-operative admissions are the rule. Surveillance for SSIs in inpatients will underestimate the true rate, since many SSIs will manifest only after discharge. Post-discharge surveillance, which refers to case identification after discharge from hospital, will therefore provide a more reliable (but sometimes significantly higher)[24] SSI rate compared with inpatient surveillance, and may identify those who are more likely to develop infection.

Different methods of post-discharge surveillance have been used with varying rates of success including patient questionnaires or letters, phone calls, or direct examination by a healthcare professional.[25-28] Regardless of the method used, no specific method has proven to be consistently reliable.

Syndromic Surveillance

Syndromic surveillance "provides an indication of disease patterns, a method for detecting aberrations in health data, or a signal that an event of public health concern is occurring."[29] While there is no consistently accepted definition, syndromic surveillance is intended to provide an early warning of disease outbreaks and facilitate an effective, timely public health response.

Data used for syndromic surveillance may include signs and symptoms of specific diseases (e.g., influenza, SARS, haemorrhagic fever), or may be non-specific to identify trends in disease processes (sometimes before a definitive diagnosis is established).[30] Healthcare facilities may be valuable sources of data, providing diagnoses or presenting complaints from patient registration databases or medical records. Examples of other data that can be used include health-related information such as over the counter or prescription medica-

tion sales (e.g., cold medications, antiviral prescriptions, antibiotics).

Minimal Requirements for Surveillance in Low Resource Settings

Performing accurate and reliable surveillance may be challenging even in the most well-resourced settings, where multiple data sources are accessible to the surveillance team, information technology services and computer infrastructure are well established, and dedicated trained personnel (i.e., infection control professionals) are present. In resource-limited settings that may be lacking in one or more of these dimensions, the following may be considered as minimum requirements for surveillance.

1. Assess the population. Even the most basic surveillance programs must consider the types of patients receiving care, and the types of services the facility provides, to determine the risks of infection.
2. Select processes or outcomes for surveillance. Identifying and measuring the most important outcomes, and limiting process measures to those that are most important in the patient population, can conserve time and other resources in limited settings.
3. Use surveillance definitions. The basic principles outlined above apply to resource-limited settings. For some surveillance activities, collecting limited data may be simpler and more time efficient, with less dependence on other resources. For example, the ECDC suggests that use of a "light" surveillance protocol for specific surveillance activities (e.g., intensive care unit (ICU) surveillance, SSI surveillance), in which detailed data are obtained only for HAI cases and denominators are unit or procedure-based aggregates, may be appropriate.[9]
4. Collect surveillance data. Because data collection can be labour and time intensive, and many resource-limited settings will not have access to computerized data, other individuals may need to be trained to assist with data collection. Severely resource-limited settings may consider conducting repeated point prevalence surveys that can identify high-risk areas requiring more attention, and to monitor HAI or process indicators in these areas. In lieu of ongoing continuous surveillance, sampling or more prolonged periodic surveillance of specific programs or procedures can also save time and resources; for example, SSI or ICU surveillance might be conducted for only three months each year instead of 12, recognizing that seasonal or other unexpected variation may be missed.
5. Analyse and interpret data. In smaller or more basic surveillance programs, data analysis can be simplified to provide only the most important results. Risk stratification may not be feasible for various reasons (e.g., missing data, or inadequate training or resources) and can be omitted, although this may limit comparisons with other organizations or published benchmarks.
6. Report and use surveillance information. In any system, it is critical that surveillance information is provided to and used by the relevant stakeholders ; failure of either renders the surveillance program meaningless.
7. Evaluate the program. Surveillance activities should be evaluated periodically in any surveillance program. At a minimum, assessment of the acceptability of the surveillance program, the quality of the data, and any changes in the patient population that impact the relevance of the surveillance program should be conducted.

Summary

Surveillance is a fundamental activity of any infection prevention program. When well-planned and implemented, a surveillance program can be one of the most powerful tools that an infection prevention and control expert brings to the organization. Surveillance data can indicate the need to make changes in clinical or organizational practices, track progress when implementing changes, and demonstrate the success or failure of what has been accomplished. Moreover, surveillance can provide compelling evidence for the need to adequately resource the infection prevention and control program, and to so positively impact the patients served.

References

1. Centers for Disease Control and Prevention. Updated guidelines for evaluating public health surveillance systems: recommendations from the guidelines working group. *Morb Mort Wkly Report* 2001;50(No. RR -13):2.
2. Langmuir AD. The surveillance of communicable diseases of national importance. *N Engl J Med* 1963;268:182-92.
3. Crosby EL. Prevention and control of staphylococcal infections in hospitals (Bulletin I) May 21, 1958. Reprinted in: *Am J Publ Health* 1958;48:1071-4.
4. Haley RW, Culver DH, White JW, et al. The efficacy of infection surveillance and control programs in preventing nosocomial infections in US hospitals. *Am J Epidemiol* 1985; 121:182-205.
5. Rosenthal VD, Maki DG, Graves N. The International Nosocomial Infection Control Consortium (INICC): goals and objectives, description of surveillance methods, and operational activities. *Am J Infect Control* 2008;36:e1-12.
6. Edwards JR, Peterson KD, Banerjee S, et al. National Healthcare Safety Network (NHSN) report: data summary for 2006 though 2008, issued December 2009. *Am J Infect Control* 2009;37:783-805.
7. Lee TB, Montgomery OG, Marx J, Olmsted RN, Scheckler WE. Recommended practices for surveillance: Association for Professionals in Infection Control and Epidemiology (APIC), Inc. *Am J Infect Control* 2007;35:427-440.
8. Smyth ET, McIlvenny G, Enstone JE, et al. Hospital Infection Society Prevalence Survey Steering Group. Four Country Healthcare Associated Infection Prevalence Survey 2006: overview of the results. *J Hosp Infect* 2008;69:230-48.
9. European Centre for Disease Prevention and Control. *Point prevalence survey of healthcare-associated infections and antimicrobial use in European acute care hospitals – protocol version 4.3.* Stockholm: ECDC; 2012. Available online at: http://ecdc.europa.eu/en/publications/publications/0512-ted-pps-hai-antimicrobial-use-protocol.pdf [Accessed 11 October 2016]
10. Stone ND, Ashraf MS, Calder J, et al. Surveillance definitions of infections in long-term care facilities: revisiting the McGeer criteria. *Infect Control Hosp Epidemiol* 2012;33:965-77.
11. Association for Professionals in Infection Control and Epidemiology, Inc. *APIC-HICPAC surveillance definitions for home health care and home hospice infections.* February 2008. http://www.apic.org/Resource_/TinyMceFileManager/Practice_Guidance/HH-Surv-Def.pdf. [Accessed 11 October2016]
12. Peterson LR, Brosette SE. Hunting health care-associated infections from the clinical microbiology laboratory: passive, active, and virtual surveillance. *J Clin Microbiol* 2002;40:1-4.
13. Hiepel D, Ober JF, Edmond MB, Bearman BML. Surgical site infection surveillance for neurosurgical procedures: a comparison of passive surveillance by surgeons to active surveillance by infection control

professionals. *Am J Infect Control* 2007;35:200-2.

14. Rosenthal VD, Bijie H, Maki DG, et al. International Nosocomial Infection Control Consortium (INICC) report, data summary of 36 countries, for 2004-2009. *Am J Infect Control* 2012;40:396-407.
15. Rosenthal VD, Maki DG, Maki DG et al. International Nosocomial Infection Control Consortium (INICC) report, data summary of 43 countries for 2007-2012. Device-associated module. *Am J infect Control* 2015;42:942-56.
16. Mangram AJ, Horan TC, Oearson ML, Silver LC, Jarvis WR. Guidelines for prevention of surgical site infection, 1999. Centers for Disease Control and Prevention (CDC) Hospital Infection Control Practices Advisory Committee. *Am J infect Control* 1999;27:97-132.
17. Centers for Disease Control and Prevention. *NHSN guidance for missing device-associated denominator data.* September 2013. Available online at: www.cdc.gov/nhsn/PDFs/NHSNMissingDenomData_Sep2013.pdf. [Accessed 11 October 2016]
18. Thompson ND, Edwards JR, Bamberg W, et al. Estimating central-line associated bloodstream infection incidence rates by sampling of denominator data: a prospective, multicenter evaluation. *Am J Infect Control* 2015;43:853-6.
19. Klevens RM, Tokars JI, Edwards J, Horan T, and the National Nosocomial Infections Surveillance (NNIS) System. Sampling for collection of central line-day denominators in surveillance of healthcare-associated bloodstream infections. *Infect Control Hosp Epidemiol* 2006;27:338-42.
20. McLaws ML, Taylor P. The Hospital Infection Standardised Surveillance (HISS) programme: analysis of a two-year pilot. *J Hosp Infect* 2003;53 (4): 260-268.
21. Allegranzi B, Nejad SB, Combescure C, et al. Burden of endemic health-care-associated infection in developing countries: systematic review and meta-analysis. *Lancet* 2011;377:228-41.
22. Rosenthal VD. Health-care-associated infections in developing countries. *Lancet* 2011; 377:186-8.
23. Rutledge-Taylor K, Matlow A, Gravel D, et al. A point prevalence survey of health-care associated infections in Canadian pediatric inpatients. *Am J Infect Control* 2012;40:491-6.
24. Holtz TH, Wenzel RP. Postdischarge surveillance for nosocomial wound infection: a brief review and commentary. *Am J Infect Control* 1992;20:206-13.
25. Petherick ES, Dalton JE, Moore PJ, Cullum N. Methods for identifying surgical wound infection after discharge from hospital: a systematic review. *BMC Infect Dis* 2006;6:170.
26. Guerra J, Guichon C, Isnard M, et al. Active prospective surveillance study with post-discharge surveillance of surgical site infections in Cambodia. *J Infect Publ Health* 2015;8:298-301.
27. Halwani MA, Turnbull AE, Marris M, Witter F, Perl TM. Postdischarge surveillance for infection following cesarean section: a prospective cohort study comparing methodologies. *Am J Infect Control* 2015 Dec 16. pii: S0196-6553(15)01109-8. doi: 10.1016/j.ajic.2015.10.023. [Epub ahead of print].
28. Elbur AI, Yousif MA, ElSayed ASA, Abdel-Rahman ME. Post-discharge syrveillance of wound infections by telephone calls method in a Sudanese teaching hospital. *J Infect Publ Health* 2013;6:339-46.
29. Paterson BJ, Durheim DN. The remarkable adaptability of syndromic surveillance to meet public health needs. *J Epidemiol Glob Health* 2013;3:41-7.
30. Katz R, May L, Baker J, Test E. Redefining syndromic surveillance. *J Epidemiol Glob Health* 2011;1:21-31.

Additional Resources

Ontario Agency for Health Protection and Promotion (Public Health Ontario), Provincial Infectious Diseases Advisory Committee. Best practices for surveillance of health care-associated infections inpatient and resident populations. http://www.publichealthontario.ca/en/eRepository/Surveillance_3-3_ENGLISH_2011-10-28%20FINAL.pdf. [Accessed 11 October 2016].

Epi Info, a free statistical software package, can be downloaded from the Centers for Diseases Control and Prevention, http://wwwn.cdc.gov/epiinfo/html/downloads.htm. [Accessed 11 October 2016].

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