Best Practices for Surveillance of Health Care-associated Infections

In Patient and Resident Populations, 3rd edition

Provincial Infectious Diseases Advisory Committee (PIDAC)

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This document was developed by the Provincial Infectious Diseases Advisory Committee on Infection Prevention and Control (PIDAC-IPC). PIDAC-IPC is a multidisciplinary scientific advisory body that provides evidence-based advice to Public Health Ontario (PHO) regarding multiple aspects of infectious disease identification, prevention and control. PIDAC-IPC's work is guided by the best available evidence and updated as required. Best Practice documents and tools produced by PIDAC-IPC reflect consensus positions on what the committee deems prudent practice and are made available as a resource to public health and health care providers.

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NOTE: This document is intended to provide best practices only. Health care settings are encouraged to work towards these best practices in an effort to improve quality of care.

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Surveillance of health care-associated infections in patient and resident populations, 3rd edition

This document is current to February, 2014. New material in this revision is highlighted in mauve in the text (or grey for black-and-white printers).

Summary of Major Revisions:

Page	Revision
12	■ New abbreviations
13-17	■ New glossary items
20	■ New symbol used to indicate "In the Know", emerging information on practices or trends
24, 31	■ Inclusion of mandatory reporting requirements for Ontario
24-25	■ Additional evidence to justify the need for surveillance systems in health care
27	■ Additional information related to use of surveillance information
34, 36	■ Additional information about the use of case definitions for surveillance
37	■ Additional information to assist in determining if an infection is nosocomial
40-41	■ Clarification of information about sensitivity and specificity
45-46	■ Information about electronic information systems for surveillance
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70	■ Additional information about benchmarks
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98	■ Appendix D - revised case definitions for HAI surveillance in long-term care homes
116	■ New Appendix J - NHSN procedure categories

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Best Practices for Surveillance of Health Care-associated Infections in Patient and Resident Populations

Executive Summary

This document provides hospitals and long-term care homes with recommended best practices for the establishment of a surveillance system to detect health care-associated infections (HAIs) within their facility.

What is Surveillance?

Surveillance is the systematic, ongoing collection, collation and analysis of data with timely dissemination of information to those who require this information in order to take action. The actions usually relate to improvements in prevention or control of the condition. Surveillance for health care-associated infections is normally performed by trained infection prevention and control professionals or hospital epidemiologists.

Why do Surveillance?

Health care-associated infections are an important hospital and public health concern in Canada. The prevalence of both antibiotic-resistant organisms and of a vulnerable, immunocompromised population are increasing in hospitals and long-term care homes. There is conclusive evidence to show that the establishment of a surveillance system for HAIs is associated with reductions in infection rates. Surveillance is also useful in monitoring the effectiveness of preventive and infection control programs and is required for patient safety and mandatory reporting requirements in Ontario.

How is Surveillance Performed?

There are several established components to an active, effective surveillance system:

1. Planning

Because it is not feasible to monitor all types of infections at all times, choosing which infections will be surveyed is based upon an initial assessment that will establish the priorities for the surveillance system.

An initial assessment will include:

- the types of patients/residents that are served by the health care setting
- the key medical interventions and procedures that are provided in the health care setting
- the frequency of particular types of infections within a particular health care setting
- the impact of the infection (including per cent case fatality and excess costs associated with the infection)
- the preventability of the infection
- required mandatory reporting elements (e.g., antibiotic-resistant organisms, ventilator-associated pneumonia).

2. Data Collection

Collection of infection data for surveillance purposes must be done using validated, published definitions for HAIs. If the definitions that are used to categorize an infection are not standardized, a health care setting's infection rates cannot be accurately compared to either their own historical infection rates or to external benchmarks.

In order to generate valid HAI rates, information must be collected on those who are at risk of getting an HAI (*denominator*) and those who actually develop an HAI (*numerator*). Electronic screening of

patient records is an emerging tool for identification of potential HAIs. These computerized systems of case finding will reduce the time spent by Infection Control Professionals (ICPs) in case finding.

Long-term care homes will have a more limited range of information available for case finding, relying on ongoing contact and feedback from those directly involved in resident care.

Post-discharge surveillance for surgical site infection is becoming an increasingly important component of a surveillance system in acute care, due to shorter hospital stays following surgeries and an increasing proportion of surgeries taking place in the outpatient setting. Innovative strategies that do not put undue burden on their program resources are encouraged in hospitals to detect surgical site infections.

3. Data Analysis

The recommendation is to calculate incidence density rates in hospitals and long-term care homes (i.e., the measurement of new cases of infection (*incidence*) during a defined period of risk in the patient/resident population, e.g., length of stay in a hospital or long-term care home). Where medical devices are inserted and/or surgical procedures are performed, rates of device-associated or surgical site infection should also be calculated on an ongoing basis. It may be useful in hospitals to stratify rates of surgical site infections by standardized risk ratios/rates in order to compare the rates to other hospitals.

An electronic spreadsheet/database and/or statistical analysis program should be used in hospitals and long-term care homes to store data and calculate HAI rates, to maximize infection prevention and control resources and reduce the potential for errors associated with manual calculations.

4. Interpretation of Data

Surveillance data require interpretation to identify areas where improvements to infection prevention and control practices can be implemented to lower the risk of HAI. Increases to a health care setting's HAI rate should trigger an investigation to look for changes in the hospital or long-term care home's activities that may explain the apparent change in the rate of infection. This investigation is particularly essential where major deviations from the baseline HAI rate may indicate the presence of an outbreak. Analysis and interpretation of infection data may be done with the facility's Infection Prevention and Control Committee or other advisory body to the Infection Control Team.

HAI rates may be compared to both the facility's own previous HAI rates and benchmarks, or to external standards or benchmarks set by other health care settings. When comparing HAI rates to those of other health care settings, it is essential that the same case finding methods are used, the same case definitions are applied and the same methods for risk stratification are employed. Recommended practice is that a set of peer facilities that serve a similar case mix, use the same case definitions and similar case finding methods be identified to serve as a comparison group.

5. Communication of Results

Communication of surveillance data should take place on an ongoing, systematic basis and be targeted to those with the ability to change infection prevention and control practice. Communication may be targeted to:

- a health care setting's Infection Prevention and Control Committee, which provides an aggregate picture of all infections of interest in the hospital
- a particular patient/resident care area or specialty care area, focused on the risk of specific types of infections that are of importance to these groups
- patient/resident care staff following the identification of an emerging risk of infection, to remind or notify of the required precautions in infection prevention and control
- local public health unit when there is a reportable communicable disease event.

6. Evaluation

Periodic review of the surveillance system should be part of regular Infection Prevention and Control Committee meetings in hospitals and long-term care homes and should include an assessment of the

outcomes to which the surveillance system contributes. Evaluation should include how information produced by a surveillance system is used to reduce the risk of health care-associated infection. Outcome evaluation should take place at least annually and a realignment of surveillance objectives undertaken when indicated.

The steps provided in this best practices guide will assist infection prevention and control professionals to develop and implement their surveillance programs in a manner that will permit comparisons with their peers and allow them to quickly detect early increases in health care-associated infections that may indicate the presence of an outbreak.

Abbreviations

ARI	Acute Respiratory Infection
ARO	Antibiotic-resistant Organism
ASA	American Society of Anesthesiologists
BSI	Bloodstream Infection
CABG	Coronary Artery Bypass Graft
CAUTI	Catheter-associated Urinary Tract Infection
CCC	Complex Continuing Care
CDI	*Clostridium difficile* Infection
CLABSI	Central Line-associated Bloodstream Infection
CNISP	Canadian Nosocomial Infection Surveillance Program
CPE	Carbapenemase-producing *Enterobacteriaceae*
CVC	Central Venous Catheter
ECDC	European Centre for Disease Prevention and Control
ESBL	Extended-spectrum Beta Lactamase
GI	Gastrointestinal Illness
HAI	Health Care-associated Infection
HFN	Health File Number
ICP	Infection Prevention and Control Professional
ICU	Intensive Care Unit
ILI	Influenza-like Illness
IPAC	Infection Prevention and Control
LTC	Long-term Care
MRSA	Methicillin-resistant *Staphylococcus aureus*
NHSN	National Healthcare Safety Network
PHAC	Public Health Agency of Canada
PHO	Public Health Ontario
PHU	Public Health Unit
OHS	Occupational Health and Safety
RICN	Regional Infection Control Networks
SD	Standard Deviation
SENIC	Study on the Effectiveness of Nosocomial Infection Control
SIR	Standardized Infection Ratio
SSI	Surgical Site Infection
UTI	Urinary Tract Infection
VAE	Ventilator-associated Event
VAP	Ventilator-associated Pneumonia
VRE	Vancomycin-resistant Enterococcus

Glossary of Terms

Active Surveillance for Health Care-associated Infections: The direct and vigorous search for information on the occurrence of health care-associated infections in order to detect a change or trend in incidence rate. This is in contrast to passive surveillance, where data are not actively solicited. See also, *Passive Surveillance for Health Care-associated Infections*, below.

Acute Respiratory Infection (ARI): Any new onset acute respiratory infection that could potentially be spread by the droplet route (either upper or lower respiratory tract), which presents with symptoms of a new or worsening cough or shortness of breath and often fever (also known as febrile respiratory infection, or FRI). It should be noted that elderly people and people who are immunocompromised may not have a febrile response to a respiratory infection.

Antibiotic-Resistant Organism (ARO): A microorganism that has developed resistance to the action of several antimicrobial agents and that is of special clinical or epidemiological significance (e.g., MRSA, VRE, ESBL, CPE).

Benchmark: A validated measure that may be used for comparison provided data are collected in the same way as that of the benchmark data. Benchmarks are used to compare HAI rates to data that use the same definitions for infection and are appropriately adjusted for patient risk factors so that meaningful comparisons can be made. Comparing HAI rates to a validated benchmark will indicate whether the rates are below or above the recognized average.

Canadian Nosocomial Infection Surveillance Program (CNISP): The Public Health Agency of Canada's (PHAC) Centre for Infectious Disease Prevention and Control (CIDPC) and the Association of Medical Microbiology and Infectious Disease (AMMI) Canada partner in this national health care surveillance project. CNISP has two main areas of activity: (1) monitoring of important nosocomial pathogens (e.g., MRSA, *C. difficile*, VRE, ESBL, CPE); and (2) surveillance of specific types of health care-associated infections including those associated with central venous catheters, ventricular shunts and other surgeries. Fifty-four sentinel hospitals from ten provinces participate in CNISP surveillance projects.

Complex Continuing Care (CCC): Complex continuing care provides continuing, medically complex and specialized services to both young and old, sometimes over extended periods of time. Such care also includes support to families who have palliative or respite care needs. It plays an integral role in the treatment offered in Ontario hospitals.

Data Mining: The process of sorting through large amounts of data and picking out relevant information. An example of data mining for surveillance is the extraction of patients with symptoms or diagnostic test results that indicate potential cases with health care-associated infection from large patient information systems.

Denominator: Represents the population at risk.

Endemic: The constant presence of a disease or infectious agent within a certain area.

Endemic Rate: A baseline or expected rate of infection.[1] Knowledge of the endemic rate of infection in a hospital or long-term care home can assist in identifying major deviations from this baseline that may indicate the presence of an outbreak. More importantly, through surveillance, hospitals and long-term care homes can evaluate whether reductions to endemic rates resulted following modifications to infection prevention and control practices.

Hawthorne Effect: An improvement caused by observing staff performance.

Health Care-associated Infection (HAI): A term relating to an infection that is acquired during the delivery of health care that was not present or incubating at the time of admission. Includes infections acquired in a hospital but appearing after discharge. It also includes such infections among staff. (Also known as *nosocomial infection*).

Health Care Facility: A set of physical infrastructure elements supporting the delivery of health-related services. A health care facility does not include a client/patient/resident's home or physician offices where health care may be provided.

Health Care Setting: Any location where health care is provided, including settings where emergency care is provided, hospitals, complex continuing care, rehabilitation hospitals, long-term care homes, mental health facilities, outpatient clinics, community health centres and clinics, physician offices, dental offices, offices of allied health professionals, public health clinics and home health care.

Hospital-wide Surveillance: All care areas are continuously and prospectively surveyed for all conditions or events of interest.

Incidence Density: The measurement of new cases of infection (incidence) based on the time at risk in the patient population (e.g., length of stay in hospital, length of exposure to a device). An incidence density rate expresses the risk of infection in '*person time*', or the amount of time that a person spends at risk.[1]

Incidence Rate: A measurement of new cases of disease occurring within a population over a given period of time. The numerator is the number of new cases detected and the denominator is the initial population at risk for developing the particular infection or event during a given time frame.[2]

Infection Prevention and Control (IPAC): Evidence-based practices and procedures that, when applied consistently in health care settings, can prevent or reduce the risk of transmission of microorganisms to health care providers, other clients/patients/residents and visitors.

Infection Prevention and Control Professional(s)(ICPs): Trained individual(s) responsible for a health care setting's infection prevention and control activities. In Ontario, an ICP must receive a minimum of 80 hours of instruction in an IPAC Canada-endorsed infection control program within six months of entering the role and must acquire and maintain Certification in Infection Control (CIC®) when eligible. The ICP should maintain a current knowledge base of infection prevention and control information.

Infection Risk: The probability that a patient/resident will acquire an infection based on the characteristics of the individual, the inherent risks associated with a procedure, or other factors that might put the individual at risk for a health care-associated infection.

Inter-rater Reliability: A measurement of the agreement between two individuals, for example in coding or diagnosis. In surveillance of HAIs, the inter-rater reliability for identification of HAIs might be assessed by having two ICPs apply a case definition for infection to a case series of potential infections. The degree of agreement would then be the proportion of cases that were defined in the same way by each ICP.

IPAC Canada: Infection Prevention and Control Canada, a professional organization of persons engaged in infection prevention and control activities in health care settings. IPAC Canada members include infection prevention and control professionals from a number of related specialties including nurses, epidemiologists, physicians, microbiology technologists, public health and industry. The IPAC Canada website is located at: www.ipac-canada.org.

Long-Term Care (LTC): A broad range of personal care, support and health services provided to people who have limitations that prevent them from full participation in the activities of daily living. The people who use long-term care services are usually the elderly, people with disabilities and people who have a chronic or prolonged illness.

National Healthcare Safety Network (NHSN): The Centers for Disease Control's (CDC) National Healthcare Safety Network is the most widely used healthcare-associated infection tracking system in the United States. NHSN provides facilities, states, regions and the nation with data needed to identify problem areas, measure progress of prevention efforts and ultimately eliminate healthcare-associated infections. NHSN now serves more than 11,000 medical facilities tracking HAIs. Data are posted publicly. NHSN was previously known as the National Nosocomial Infections Surveillance (NNIS) System. More information is available at: www.cdc.gov/nhsn/.

NHSN SSI Risk Index: In use by NHSN up to 2011, the risk index is a score used to predict a patient's risk of acquiring a surgical site infection. The risk index score, ranging from 0 to 3, indicates the number of infection risk factors present. One point is scored for each of the following: a) a patient with an American Society of Anesthesiologists' (ASA) physical status classification score of 3, 4, or 5; b) an operation classified as contaminated or dirty/infected; and c) an operation lasting greater than *T* hours, where *T* is the recommended average operation length of time assigned to the operation being performed. NHSN now applies Standardized infection ratios (SIR).

Nosocomial: Arising while a patient is in a hospital or as a result of being in a hospital. Denoting a new disorder (unrelated to the patient's primary condition) associated with being in a hospital.

Nosocomial Infection: See *Health Care-associated Infection*.

Numerator: Each event/infection that occurs during the surveillance period.

Ontario Agency for Health Protection and Promotion (OAHPP): An arm's-length government agency dedicated to protecting and promoting the health of all Ontarians and reducing inequities in health. OAHPP was created by legislation in 2007 and began operations in July 2008 with a mandate to provide scientific and technical advice to those working to protect and promote the health of Ontarians. It's vision is to be an internationally recognized centre of expertise dedicated to protecting and promoting the health of all Ontarians through the application and advancement of science and knowledge. OAHPP's operating name is Public Health Ontario (PHO). More information is available at: www.publichealthontario.ca.

Outbreak: For the purposes of this document, an outbreak is an increase in the number of cases above the number normally occurring in a particular health care setting over a defined period of time.

Outcome surveillance: Surveillance used to measure client/patient/resident outcomes (changes in the client/patient/resident's health status that can be attributed to preceding care and service). An example of outcome surveillance related to infection prevention and control is surveillance of HAI rates. Outcome surveillance reflects the efficacy of the infection prevention and control program in protecting clients/patients/residents, health care providers and visitors from health care-associated infections while decreasing costs from infections.

Passive Surveillance for Health Care-associated Infections: Identification of health care-associated infections through established event reporting procedures by staff whose primary responsibility is patient/resident care. This is in contrast to active surveillance, where data are actively solicited. See also, *Active Surveillance for Health Care-associated Infection*, above.

Patient/Resident: Any person receiving care within a hospital or long-term care home.

Periodic Surveillance for Health Care-associated Infections: Surveillance undertaken over a specified time interval (e.g., one month each quarter) in a health care setting. Some infection prevention and control programs will conduct surveillance on one or more units for a period of time and then shift to another unit or group of units. This rotation provides a less costly method to collect information on all high risk patient care areas.

Prevalence Survey for Health Care-associated Infections: Surveillance for all existing and new health care-associated infections in a health care setting either on a single day (*point prevalence*) or over a specified number of days (*period prevalence*). Data from each patient/resident is collected only once. A prevalence survey can provide a rapid, inexpensive way to estimate the global view and magnitude of health care-associated infections in a health care setting at a single point in time. It should also be noted that while a prevalence survey provides a picture of health care-associated infections at a single point in time, this risk estimate can be affected by the context for infection at that time. For instance, a prevalence survey for health care-associated respiratory infections during the winter months may indicate a higher risk of infection due to the seasonal occurrence of these events.

Process Surveillance: Surveillance used to assess or measure client/patient/resident processes (things done to or for a patient/resident during their encounter with the health care system). An example of process surveillance related to infection prevention and control is planned audits to verify that procedures and/or standards of practice are being followed.

Provincial Infectious Diseases Advisory Committee (PIDAC): A multidisciplinary, scientific advisory body of Public Health Ontario that provides evidence-based advice regarding multiple aspects of infectious disease identification, prevention and control. More information is available at: www.publichealthontario.ca/en/BrowseByTopic/InfectiousDiseases/PIDAC/Pages/PIDAC.aspx.

Public Health Agency of Canada (PHAC): A national agency that promotes improvement in the health status of Canadians through public health action and the development of national guidelines. The PHAC website is located at: www.phac-aspc.gc.ca.

Public Health Ontario (PHO): Created June 14, 2011, Public Health Ontario is the operating name for OAHPP.

Public Health Unit (PHU): An official health agency established by a group of urban and rural municipalities to provide a more efficient community health program, carried out by dedicated, specially qualified staff. There are 36 public health units in Ontario. Health units administer health promotion and disease prevention programs to inform the public about healthy life-styles, communicable disease control, immunization and food premises inspection.

Regional Infection Control Networks (RICN): The RICN of Ontario coordinate and integrate resources related to the prevention, surveillance and control of infectious diseases across all health care sectors and for all health care providers, promoting a common approach to infection prevention and control and utilization of best-practices within the region. There are 14 regional networks in Ontario. More information is available at: www.publichealthontario.ca/en/About/Departments/Pages/Regional_Infection_Control_Networks.aspx

Reportable Disease: Under the Health Protection and Promotion Act, physicians, nurses, and other practitioners including chiropractors, dentists, optometrists, and pharmacists have a legal obligation to report a suspect or confirmed case of a reportable communicable disease to their local Medical Officer of Health. The list of reportable diseases in Ontario is available at: www.e-laws.gov.on.ca/html/regs/english/elaws_regs_910559_e.htm

Risk Stratification: A process to control for differences in the underlying risk factors for infection. Risk stratification involves calculating separate rates for patients/residents with similar susceptibilities to health care-associated infections, or those in the same category of risk (e.g., surgeon-specific infection rates).
Sensitivity: Percentage of persons with true positive results among persons known to have a disease.

Sentinel Event: A colonization/infection in which the occurrence of perhaps even a single case may signal the need to re-examine preventive practices.

Specificity: Percentage of persons with true negative results among persons without the disease.

Standard Deviation (SD): The average spread or dispersion around the mean rate, i.e., data values will lie somewhere above or below the average that has been calculated from all of the values.

Standardized Infection Ratio (SIR): The SIR is a summary measure used to track healthcare-associated infections over time. The SIR adjusts for the fact that each healthcare facility treats different types of patients in terms of demographics and disease severity. The SIR compares the number of infections to the number of infections that would be predicted based on national and historical baseline data (current reference period is 2006-2008). SIR was implemented by NHSN in 2012.

Surveillance: The systematic, ongoing collection, collation and analysis of data with timely dissemination of information to those who require it in order to take action.[12]

Syndromic Surveillance: The detection of individual and population health indicators of illness (i.e., signs and symptoms of infectious disease) that is discernible before confirmed laboratory diagnoses are made.

Targeted Surveillance: Surveillance that is focused on certain health care setting areas (e.g., intensive care unit), patient populations (e.g., surgical patients) and/or infection types (e.g., bloodstream infections, indwelling catheter-associated urinary tract infections), that have been identified as a priority within the health care setting.

Ventilator-Associated Event (VAE): A surveillance definition developed by the NHSN to identify a broad range of conditions and complications occurring in mechanically-ventilated adult patients. VAEs are identified by using a combination of objective criteria: deterioration in respiratory status after a period of stability or improvement on the ventilator, evidence of infection or inflammation, and laboratory evidence of respiratory infection. There are three definition tiers within the VAE algorithm: 1) Ventilator-associated condition (VAC); 2) Infection-related ventilator-associated complication (IVAC); and 3) Possible and probable ventilator-associated infection (VAP).

Ventilator-Associated Pneumonia (VAP): Pneumonia resulting in patients undergoing mechanical ventilation. In Ontario, VAP reporting is mandatory and has a standardized case definition. See Appendix C for more information.

I. Preamble

A. About this Document

This document is intended as a guide for Infection Control Professionals (ICPs) in acute and long-term care, to ensure that the critical elements and methods of surveillance for health care-associated infections (HAIs) are incorporated into their practice. It provides guidance for each of the building blocks of the surveillance system including planning, data collection, interpretation, analysis and communication, to inform infection prevention and control practices that will result in effective surveillance in hospitals and long-term care homes.

The best practices for surveillance described in this document should assist acute and long-term care settings in Ontario in establishing surveillance systems. Effective surveillance should lead to process improvements that will result in decreases in HAI rates, morbidity, mortality and health care costs. Although the primary audience for this document comprises those directly involved in surveillance, it also serves as a resource for anyone seeking to improve their understanding of best practices for surveillance of health care-associated infections.

The best practices in this document recommend a standardized approach to the surveillance of health care-associated infections that will allow for the comparison of rates within facilities, across facilities as well as comparison to provincial (e.g., Ontario's patient safety indicators) and national benchmarks (e.g., Canadian Nosocomial Infection Surveillance Program). This document forms one component of an effort to enhance patient safety and improve the quality of health care in Ontario.

B. Evidence for Recommendations

The principles and practices recommended in this document are a synthesis of the best available scientific evidence and expert opinion of professionals from the fields of infectious diseases, infection prevention and control, public health and epidemiology. As new information becomes available, recommendations in this document will be reviewed and updated.

C. How and When to Use This Document

The types of health care settings to which the guidance provided in this document applies are outlined in Box 1.

Box 1: Health Care Settings Impacted by this Document

This document applies to these health care settings:

- Hospitals (tertiary care, community care, mental health, rehabilitation, etc.)
- Long-term/chronic care homes
- Complex continuing care settings

This document does not apply to these health care settings:

- Primary care
- Community health settings (clinics, physician offices, dental offices)
- Home health care

D. Limitations to this Document

This document deals with the surveillance of infections that arise during the delivery of health care, rather than on the processes contributing to changes in the risk of acquiring health care-associated infections. Monitoring of processes, such as hand hygiene and sterilization techniques, are addressed through the health care setting's practice audits, rather than through the outcome surveillance systems as described in this best practices guide. For more information regarding process surveillance, see the Provincial Infectious Diseases Advisory Committee (PIDAC)'s *Best Practices for Infection Prevention and Control Programs in Ontario in All Health Care Settings*.[3]

This document does not prescribe how much surveillance should be done in individual facilities, nor does it dictate what should be surveyed. It is acknowledged that different facilities may implement these best practices in different ways, depending on resources and local circumstances. For more information regarding recommendations for surveillance targets, see PIDAC's *Best Practices for Infection Prevention and Control Programs in Ontario in All Health Care Settings*.[3]

This document provides guidance for routine surveillance programs and is not intended as a guide for infection surveillance during outbreaks. However, it is recognized that baseline HAI rates established by a well-functioning, ongoing surveillance system are essential to assist in outbreak identification by indicating increases above the norm. Once an outbreak is suspected, health care settings must notify their local Medical Officer of Health (institutional outbreaks are reportable under the *Health Protection and Promotion Act*[4]) and outbreak management should be undertaken in collaboration with the local public health.

Specific surveillance recommendations for antibiotic-resistant microorganisms and *Clostridium difficile* are not included in this document. Refer to the following Ontario documents for examples of specific surveillance methodologies:

- Antibiotic-resistant organism surveillance:
  Annex A: Screening, Testing and Surveillance for Antibiotic-Resistant Organisms (AROs) in All Health Care Settings.[5] Available at: www.publichealthontario.ca/en/eRepository/PIDAC-IPC_Annex_A_Screening_Testing_Surveillance_AROs_2013.pdf.
- Acute respiratory infection surveillance:
  Annex B: Best Practices for Prevention of Transmission of Acute Respiratory Infection in All Health Care Settings.[6] Available at: www.publichealthontario.ca/en/eRepository/PIDAC-IPC_Annex_B_Prevention_Transmission_ARI_2013.pdf.
- *Clostridium difficile* surveillance:
  Annex C: Testing, Surveillance and Management of Clostridium difficile in All Health Care Settings.[7] Available at: www.publichealthontario.ca/en/eRepository/PIDAC-IPC_Annex_C_Testing_SurveillanceManage_C_difficile_2013.pdf.
- Staff surveillance:
  Communicable Disease Surveillance Protocols. Ontario Hospitals Association and Ontario Medical Association. These Protocols provide direction for surveillance and management of specific infections among hospital staff. Available at: www.oha.com/SERVICES/HEALTHSAFETY/Pages/CommunicableDiseasesSurveillanceProtocols.aspx.

E. Illustrations and Symbols

Throughout the document, illustrations are used to demonstrate the concepts described in the text. These illustrations are meant as examples of how the recommended best practices outlined in this document could be applied in an acute and a long-term care setting. The illustrations used are:

- City General Hospital – a fictitious acute care hospital
- Forest Manor – a fictitious long-term care home

The following symbols are used throughout the document:

Recommended Best Practices are annotated with this symbol. These practices are recommended by PIDAC based on the best available evidence as a standardized approach to surveillance. All recommended best practices are summarized at the end of the document.

Pearls of Wisdom are annotated with this symbol and provide lessons from those with longstanding experience in the field of surveillance. Pearls of wisdom draw attention to commonly overlooked areas and, in some cases, common pitfalls in undertaking surveillance.

Surveillance Tools are annotated with this symbol and refer to a set of practical tools that may be used to implement the recommended best practices.

In the Know highlights emerging information on practices and trends that might impact on surveillance practices in the future.

F. Assumptions and General Principles

The best practices in this document are based on the assumption that health care settings in Ontario already have basic infection prevention and control (IPAC) systems and programs in place.[3] Without a basic system of infection prevention and control in place, appropriate resources for surveillance system planning, data collection and analysis as well as improvements to IPAC practices based on the information provided by the surveillance system will be difficult to identify. Health care settings that do not have Infection Control Professionals should work with organizations that have IPAC expertise, such as academic health science centres, Regional Infection Control Networks (RICN), public health units that have professional staff certified in IPAC and local IPAC associations (e.g., Infection Prevention and Control (IPAC) Canada chapters), to develop evidence-based programs.

In addition to the general assumption (*above*) regarding basic IPAC, these best practices are based on the following additional assumptions and principles:

1. Adequate resources are devoted to IPAC in all health care settings. See PIDAC's *Best Practices for Infection Prevention and Control Programs in Ontario in All Health Care Settings,*[3] available at: www.publichealthontario.ca/en/eRepository/BP_IPAC_Ontario_HCSettings_2012.pdf.

2. Programs are in place in all health care settings that promote good hand hygiene practices and ensure adherence to standards for hand hygiene. See:

    a) PIDAC's *Best Practices for Hand Hygiene in All Health Care Settings*,[8] available at: www.publichealthontario.ca/en/eRepository/2010-12%20BP%20Hand%20Hygiene.pdf.

    b) Ontario's hand hygiene improvement program, *Just Clean Your Hands*,[9] available at: www.publichealthontario.ca/en/BrowseByTopic/InfectiousDiseases/JustCleanYourHands/Pages/Just-Clean-Your-Hands.aspx.

3. Adequate resources are devoted to Environmental Services/Housekeeping in all health care settings that include written procedures for cleaning and disinfection of client/patient/resident rooms and equipment; education of new cleaning staff and continuing education of all cleaning staff; and ongoing review of procedures. See PIDAC's *Best Practices for Environmental Cleaning in All Health Care Settings*,[10] available at: www.publichealthontario.ca/en/eRepository/Best_Practices_Environmental_Cleaning_2012.pdf.

4. Best practices to prevent and control the spread of infectious diseases are routinely implemented in all health care settings, in accordance with:

    a) PIDAC'S *Routine Practices and Additional Precautions in All Health Care Settings,*[11] available at: www.publichealthontario.ca/en/eRepository/RPAP_All_HealthCare_Settings_Eng2012.pdf.

    b) PIDAC's Annex A: *Screening, Testing and Surveillance for Antibiotic-Resistant Organisms (AROs),*[5] available at: www.publichealthontario.ca/en/eRepository/PIDAC-IPC_Annex_A_Screening_Testing_Surveillance_AROs_2013.pdf.

    c) PIDAC's Annex B: *Best Practices for Prevention of Acute Respiratory Infection in All Health Care Settings,*[6] available at: www.publichealthontario.ca/en/eRepository/PIDAC-IPC_Annex_B_Prevention_Transmission_ARI_2013.pdf.

    d) PIDAC's Annex C: *Testing, Surveillance and Management of Clostridium difficile in All Health Care Settings,*[7] available at: www.publichealthontario.ca/en/eRepository/PIDAC-IPC_Annex_C_Testing_SurveillanceManage_C_difficile_2013.pdf

5. Programs are in place in all health care settings that ensure effective disinfection and sterilization of used medical equipment according to *Best Practices for Cleaning, Disinfection and Sterilization in All Health Care Settings,*[12] available at: www.publichealthontario.ca/en/eRepository/PIDAC_Cleaning_Disinfection_and_Sterilization_2013.pdf.

6. Regular education (including orientation and continuing education) and support is provided in all health care settings to help staff consistently implement appropriate IPAC practices. Effective education programs emphasize:

    - the risks associated with infectious diseases, including acute respiratory illness and gastroenteritis
    - hand hygiene, including the use of alcohol-based hand rubs and hand washing
    - principles and components of Routine Practices as well as additional transmission-based precautions (Additional Precautions)
    - assessment of the risk of infection transmission and the appropriate use of personal protective equipment (PPE), including safe application, removal and disposal
    - appropriate cleaning and/or disinfection of health care equipment, supplies and surfaces or items in the health care environment
    - individual staff responsibility for keeping clients/patients/residents, themselves and co-workers safe
    - collaboration between professionals involved in occupational health and IPAC.

NOTE: Education programs should be flexible enough to meet the diverse needs of the range of health care providers and other staff who work in the health care setting. The local public health unit and RICN may be a resource and can provide assistance in developing and providing education programs for community settings.

7. Collaboration between professionals involved in OHS and IPAC is promoted in all health care settings to implement and maintain appropriate IPAC standards that protect workers.
8. There are effective working relationships between the health care setting and local public health unit. Clear lines of communication are maintained and Public Health is contacted for information and advice as required and the obligations (under the *Health Protection and Promotion Act*, R.S.O. 1990, c.H.7)[4] to report reportable and communicable diseases is fulfilled. Public Health provides regular aggregate reports of outbreaks of reportable infectious diseases in facilities and/or in the community to all health care settings.
9. Access to ongoing IPAC advice and guidance to support staff and resolve differences are available to the health care setting.
10. There are established procedures for receiving and responding appropriately to all international, national, regional and local health advisories in all health care settings. Health advisories are communicated promptly to all affected staff and regular updates are provided. Current advisories are available from local public health units, the Ministry of Health and Long-Term Care (MOHLTC), Health Canada and Public Health Agency of Canada (PHAC) websites and local RICN.
11. Where applicable, there is a process for evaluating personal protective equipment (PPE) in the health care setting, to ensure it meets quality standards.
12. There is regular assessment of the effectiveness of the infection prevention and control program and its impact on practices in the health care setting. The information is used to further refine the program.[3]
13. Programs are in place in all health care settings to incorporate staff surveillance for occupationally-acquired infections. More information and the Communicable Diseases Surveillance Protocols may be found at: www.oha.com/services/healthsafety/pages/communicablediseasessurveillanceprotocols.aspx.

Occupational Health and Safety requirements shall be met:

- Health care facilities are required to comply with applicable provisions of the *Occupational Health and Safety Act* (OHSA), R.S.O. 1990, c.O.1 and its Regulations.[13] Employers, supervisors and workers have rights, duties and obligations under the OHSA. Specific requirements under the OHSA and its regulations are available at:
    - *Occupational Health and Safety Act*: www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_90o01_e.htm
    - *Ontario Regulation 67/93 Health care and Residential Facilities*: http://www.e-laws.gov.on.ca/html/regs/english/elaws_regs_930067_e.htm
- The *Occupational Health and Safety Act* places duties on many different categories of individuals associated with workplaces, such as employers, constructors, supervisors, owners, suppliers, licensees, officers of a corporation and workers. A guide to the requirements of the *Occupational Health and Safety Act* may be found at: www.labour.gov.on.ca/english/hs/pubs/ohsa/index.php.
- The OHSA section 25(2)(h), the '*general duty clause*', requires an employer to take every precaution reasonable in the circumstances for the protection of a worker.
- Specific requirements for certain health care and residential facilities may be found in the *Regulation for Health Care and Residential Facilities*, available at: www.e-laws.gov.on.ca/html/regs/english/elaws_regs_930067_e.htm. Under that regulation there are a number of requirements, including:

Requirements for an employer to establish written measures and procedures for the health and safety of workers, in consultation with the joint health and safety committee or health and safety representative, if any. Such measures and procedures may include, but are not limited to, the following:

- safe work practices
- safe working conditions
- proper hygiene practices and the use of hygiene facilities
- the control of infections
- immunization and inoculation against infectious diseases.

The requirement that at least once a year the measures and procedures for the health and safety of workers shall be reviewed and revised in the light of current knowledge and practice.

A requirement that the employer, in consultation with the joint health and safety committee or health and safety representative, if any, shall develop, establish and provide training and educational programs in health and safety measures and procedures for workers that are relevant to the workers' work.

A worker who is required by his or her employer or by the *Regulation for Health Care and Residential Facilities* to wear or use any protective clothing, equipment or device shall be instructed and trained in its care, use and limitations before wearing or using it for the first time and at regular intervals thereafter and the worker shall participate in such instruction and training.

The employer is reminded of the need to be able to demonstrate training, and is therefore encouraged to document the workers trained, the dates training was conducted, and the information and materials covered during training.

- Under the *Occupational Health and Safety Act*, a worker must work in compliance with the Act and its regulations, and use or wear any equipment, protective devices or clothing required by the employer.
- The Needle Safety Regulation (O.Reg 474/07)[14] has requirements related to the use of hollow-bore needles that are safety-engineered needles. The regulation is available at: www.e-laws.gov.on.ca/html/regs/english/elaws_regs_070474_e.htm.

Additional information is available at the Ministry of Labour Health and Community Care Page: www.labour.gov.on.ca/english/hs/topics/healthcare.php.

II. Best Practices for Surveillance of Health Care-associated Infections in Patient and Resident Populations

A. Purpose of Surveillance

With the emergence of antibiotic-resistant organisms (AROs) in health care settings, increasingly immunocompromised patients in acute care and increasing numbers of individuals requiring long-term care and complex continuing care, health care-associated infections (HAIs) represent an important and growing challenge to the entire health care system. A large percentage of HAIs are preventable and the scientific literature has established that incorporating surveillance systems into infection prevention and control (IPAC) activities are a means to reduce the frequency of these events.[15] Surveillance is also useful in monitoring the effectiveness of IPAC programs and is required for patient safety and mandatory reporting in Ontario.

B. What is a Surveillance System?

Surveillance is defined as "*the ongoing, systematic collection, analysis, interpretation and evaluation of health data closely integrated with the timely dissemination of these data to those who need it*".[16] There are two key aspects of surveillance systems:

- Surveillance is an organized and ongoing component of a program to improve a specific area of population health.
- Surveillance systems go beyond the collection of information. They involve mechanisms by which the knowledge gained through surveillance is delivered to those who can use it to direct resources where needed to improve health.

1. Rationale for Surveillance Systems in Acute and Long-term Care Settings

HAIs are a major and continuing challenge in hospitals and long-term care homes. Patients with one or more HAIs during their in-patient stay remain in hospital longer and incur costs on average three times greater than uninfected patients.

HAIs substantially impact the disease burden in the U.S., with approximately 1.7 million HAIs and 100,000 deaths each year.[17] It is estimated that 5% to 10% of hospitalized patients acquire an infection after admission to hospital.[18] Patients with HAI frequently require readmission or remain in hospital on average longer than patients without infection.[19-21] For example, central line-associated bloodstream infections (CLABSI) have been shown to increase hospital length of stay by 10 to 20 days.[22]

HAIs have a significant impact on health care spending, with estimates of $ 5 billion in the U.S.[23] and more than £ 900 million in the U.K. associated with the prolonged stay,[19, 20, 24] readmissions [19]and treatment costs for infections acquired in hospitals per year.[18] In 2003, on the basis of U.S. estimates, Zoutman et al.[25] calculated that the incidence of HAIs in Canada was 220,000 per year, resulting in more than 8,000 deaths. CLABSIs, especially in ICUs, cost hospitals US$ 4,000 to US$ 56,000 per infection.[22]

A 2003 study[26] projected the cost to managing patients with MRSA in Canada to be $ 42 to $ 59 million. The rapid increase of AROs has added to the impact of HAIs:

- Canadian surveillance data shows a seventeen-fold increase in the rates of methicillin-resistant *Staphylococcus aureus* (MRSA) in selected hospitals since 1995.[27, 28] The median cost associated with

MRSA is about twice the cost of methicillin-sensitive *Staphylococcus aureus* in a long-term care[29] or acute care facility.[30]

- The mean cost of interventions to reduce the rate of extended-spectrum beta lactamase-producing (ESBL) *Enterobacteriaceae* is $ 3,191 per case.[31]
- Vancomycin-resistant enterococcal (VRE) bacteremia has been associated with increased costs and increased length of stay.[32]
- *Clostridium difficile* infection (CDI) is also associated with substantial excess morbidity,[33] mortality[28, 34-36] and health care costs. In 2002, Miller et al.[37] noted the frequent occurrence of medical complications and mortality associated with nosocomial CDI. The hospital care and drug costs associated with nosocomial CDI readmissions alone were projected at $ 128,500 per hospital per year in Canada.

HAIs are also common in long-term care homes,[38] frequently resulting in death. Estimates of the rates of HAI in long-term care homes range from 3 to 7 per 1,000 patient care days,[39] which is comparable to that in the hospital setting.[40] Outbreaks in long-term care homes can be difficult to contain and result in significant cost to the organization.[41,42] As the numbers of individuals requiring long-term care is expected to rise dramatically in the coming years, increased resources for IPAC in this care setting will be an important factor to overall health.[3]

It is estimated that up to 70 per cent of HAIs are preventable.[15, 25, 43-45] Therefore, an IPAC program that is effective in preventing HAIs can substantially reduce health care costs and, more importantly, the morbidity and mortality associated with HAIs.[45-49]

2. Evidence to Support Best Practices in Surveillance

A surveillance system in hospitals and long-term care homes forms an integral part of an IPAC program aimed at reducing health care-associated infections. In order to demonstrate the impact of surveillance on HAIs in health care settings, a critical appraisal of the evidence documenting changes to the risk of infection following the establishment of a surveillance system was undertaken:

- A systematic review of the scientific literature identified several studies (Appendix B) that examined changes in the rates of HAIs following the introduction of surveillance.[15, 50-63]
- The studies compared the risk of health care-associated infection at the beginning of a surveillance program (before any impacts associated with the program could be expected) to the risk of infection after the surveillance program was established and operational.
- There was a clear connection between implementation of a surveillance program and subsequent decline in the rates of HAI. Reductions in the rates of HAIs generally ranged from 7 to 60 per cent following the implementation of surveillance programs .[15, 60]
- Several of the studies indicated that the reductions in rates of HAIs were the result of changes to IPAC practices informed by the feedback provided by the surveillance system.[51, 53, 58-60]

Refer to Appendix B for the methods used to conduct this review and the evaluative criteria applied to these studies.

There are many mechanisms through which surveillance reduces the risk of HAI in hospitals. The *Hawthorne Effect* (i.e., practices improve when increased attention is brought to them) may play a major role. Also, the presence of an Infection Control Professional (ICP) in a particular care area may increase dialogue and awareness of standards for IPAC.

Haley's 1980 landmark *Study on the Efficacy of Nosocomial Infection Control (SENIC Project)*[64] demonstrated that a comprehensive, organized surveillance system with a physician trained in IPAC and one ICP per 250 patient beds was associated with reduced rates of HAI.[15] Haley's study also found that feedback of infection rates to surgeons was an essential surveillance component to reduce surgical site infection. Both Canadian and US expert panels have used SENIC as a basis for their recommendations for essential infrastructure and personnel resources for IPAC in hospitals and long-term care homes since the publication of this study.

An inventory of resources for surveillance and IPAC activities, *Resources for Infection Control in Canadian Hospitals (RICH)*, conducted by Zoutman et al. in 2003[25] found that a substantial proportion of hospitals still lack the essential resources to carry out surveillance. RICH data also demonstrated that Canadian hospitals with sophisticated surveillance systems experienced lower rates of infections caused by AROs.[65] The RICH study was expanded to long-term care with similar findings relating to inadequately developed surveillance systems.[66]

Current recommendations for IPAC resources take into account the complexity of today's health care settings and varied case mixes.[43, 67] Health care settings are more connected locally and regionally and it is no longer effective to only manage HAIs in hospitals.[68] Larger, long-term reductions in HAI prevalence may require coordinated regional, provincial and national surveillance efforts.[69]

- More information may be found in PIDAC's *Best Practices for Infection Prevention and Control Programs in Ontario in All Health Care Settings,*[3] available at: www.publichealthontario.ca/en/eRepository/BP_IPAC_Ontario_HCSettings_2012.pdf.

Pearl of Wisdom: *An effective surveillance system will reduce the frequency of health care-associated infection.*

C. Elements of Surveillance

Surveillance systems for infections in acute care and long-term care homes serve several related purposes towards the end goal of reducing the risk of acquiring health care-associated infection:

1. Detect and Monitor

A well-functioning surveillance system provides the means to establish the endemic, or baseline, rate of HAI in a health care setting.[70-72] The vast majority of HAIs do not occur within the context of an identified outbreak, but reflect areas where improvements may be made that will result in a sustained lowering of the endemic rate. While surveillance can assist in the detection of outbreaks in hospitals and long-term care homes by identifying significant deviations from the baseline rate,[73] a more central purpose of ongoing surveillance is to monitor changes in the endemic rate of infection that indicate areas to focus improvements.[70, 72, 74, 75]

2. Identify Risk Factors for Health Care-Associated Infection

The data collected as part of a surveillance system in a health care setting can be used to identify patients or residents at high risk for HAIs or practices associated with a high risk of infection.[62, 76, 77] For example, the U.S. National Healthcare Safety Network (NHSN) data have been used to compare the risk of surgical site infection among patients undergoing open vs. laparoscopic cholecystectomy.[78]

Risk factors for HAI, such as urinary incontinence, presence of an indwelling catheter, skin ulcers and chronic conditions such as heart disease, have all been identified in the long-term care context through the use of surveillance data.[79]

3. Evaluate Preventive Interventions

Following the implementation of preventive practices, data from the surveillance system can be used to investigate whether the measures were effective in achieving their intended outcome of improved infection control.[46, 74] Data collected through surveillance can also identify ineffective IPAC measures, an example of which is provided in Box 2.

Box 2: Example of the Use of Surveillance to Identify Ineffective Practices: Discontinuation of Pre-operative Shaving Practices

In two Calgary hospitals, pre-operative shaving with razor of the intended surgical wound site was found to be associated with a higher risk of surgical site infection. Although pre-operative shaving was once thought to reduce the risk of surgical site infection, information provided by the surveillance system demonstrated a sustained decline in the risk of surgical site infection in both hospitals following the discontinuation of this practice.

Cruse PJ, Surg Clin North Am 1980

4. Provide Information to Inform, Educate and Reinforce Practice

Surveillance information can trace evolution of infection over time and inform public health practice. For example:

- Detects shifts in pattern of MRSA bacteremia from nosocomial to wider parts of the health care system.[80]
- Populations previously thought to be at low risk of CDI are now being identified as having severe CDI.[38, 81]
- Dramatic increase in the incidence of ESBL-producing *E. coli* indicates a serious threat for hospitals and communities that deserves specific control actions.[82]

The continued presence of a surveillance system can increase awareness of IPAC practices through discussions initiated by ICPs as they gather information from wards. Barwolff et al.[57] noted that the decrease in rates of surgical site infection following Caesarean delivery in several German hospitals was attributed to the increased awareness of the risks of surgical site infection and of standards in IPAC generated by the presence of the surveillance program in the obstetrics wards.

Regular contact with ICPs can also identify areas where changes to IPAC practices could lower the rates of infection in high risk areas. For example, regular contact of ward nurses with the ICP in a long-term care home over the course of an influenza season can serve to remind staff of appropriate IPAC practices (e.g., cohorting, droplet precautions) for residents developing '*influenza-like*' illnesses (ILIs).

Evidence of the effectiveness of preventive interventions in one's own health care setting also serves to reinforce practice.[83] The use of surveillance data from one's own facility, demonstrating the effect of IPAC practices on HAIs, can be successful in building awareness of the benefits of preventive practices. [169]

D. Best Practices

Different health care settings serve different patient populations, offer different diagnostic procedures and treatments and have a varying level of care that is offered in inpatient vs. outpatient settings. As a result the priorities, goals and information needs of a surveillance system will vary across health care settings.[169] Additionally, the resources available for the establishment and operation of a surveillance system are also expected to vary by facility.

The general steps required in setting up a surveillance program can be followed by any hospital or long-term care home in planning and implementing their surveillance system:[84]

- assess the population to be surveyed
- select the outcome(s) for surveillance
- use standardized, validated case definitions for infection
- use case definitions consistently over time
- collect the surveillance data

- calculate and analyze surveillance rates
- apply risk stratification methodology where applicable
- interpret HAI rates
- communicate surveillance information to stakeholders
- use surveillance information to improve practice
- evaluate the surveillance system.

Figure 1 illustrates these recommended steps within the planning, data collection, analysis, interpretation, communication and evaluation phases of surveillance.

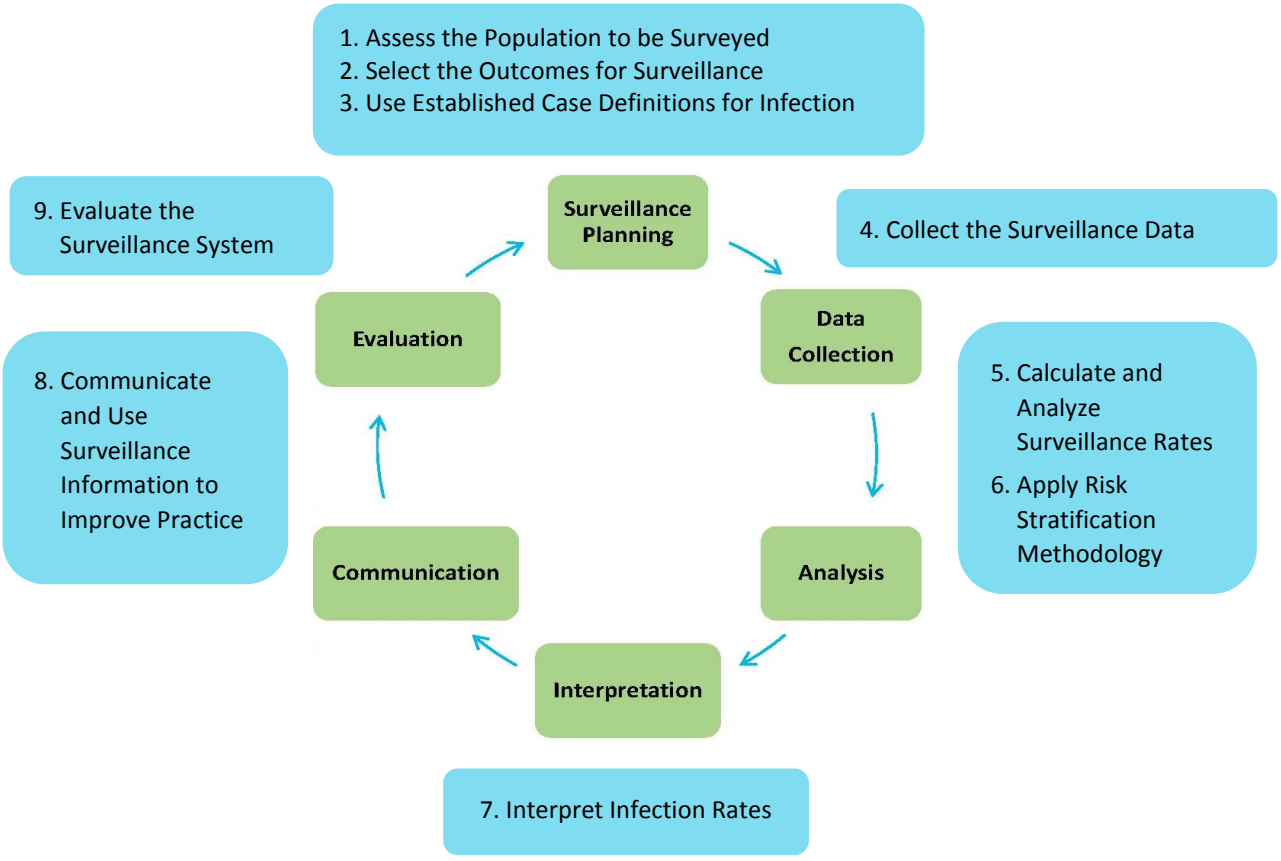


Figure 1: Steps to planning a surveillance system

1. Assess the Population to be Surveyed

As each health care setting serves different types of patients/residents who face varying levels of risk for different types of infections, an evaluation of the populations served by the hospital or long-term care home should be a first step in planning a surveillance system. This evaluation enables priorities for a surveillance system to be established. Resources for surveillance can then be targeted to the populations at risk for the outcomes of greatest importance, defined in these priority areas.

HOW TO ASSESS THE POPULATION SERVED BY A HEALTH CARE SETTING

Box 3 outlines the types of questions that can assist in the assessment of a patient population:

Box 3: Questions Assisting in Assessment of Populations Served by a Particular Hospital or Long-term Care Home[85, 87, 88]

- ✓ What is the catchment area of the hospital or long-term care home?
- ✓ What types of patients/residents are served (e.g., age distribution, socio-demographic profile)?
- ✓ What are the most common diagnoses?
- ✓ What are the most frequently performed invasive procedures (e.g., surgeries for hospitals, indwelling urinary catheters for long-term care homes)?
- ✓ Which services or treatments are utilized most frequently?
- ✓ What types of patients/residents are at greatest risk of infection?
- ✓ Are there any health concerns emerging from the community (e.g., community-associated MRSA, tuberculosis)?

Information resources specific to a particular hospital or long-term care home should be used to address these questions. Examples of some of the information resources that may be used include:[74, 85, 169]

- medical records
- financial services or information services reports
- surgical databases
- administrative/management reports[86]
- community health status reports, produced by local public health units (to identify health concerns from the surrounding community)
- regionally-collected health care data[87]
- census reports.

Information on the demographic characteristics of the population served by a health care setting, such as its age distribution, socio-economic conditions and ethnic diversity, can be obtained from the health care setting's census reports.

Recommended Best Practice #1:

As a first step in the planning of a surveillance system, a health care setting should assess:

- ***the types of patients/residents that it serves;***
- ***the key medical interventions and procedures that they undergo; and***
- ***the types of infections for which they are most at risk.***

This assessment is done to establish priorities for the surveillance system.

2. Select the Outcomes for Surveillance

Selection of the types of infections that will be surveyed should be undertaken in conjunction with an assessment of the population and identification of surveillance priorities as described above. Most IPAC programs have prioritized the types of infections for surveillance that have the most important impact on the populations that they serve.[74]

A. FACILITY-WIDE SURVEILLANCE

Facility-wide surveillance of all infections is not recommended in health care settings.[74] Facility-wide surveillance involves the prospective and continuous survey by the ICP (or the person to whom responsibility for surveillance has been designated) of all care areas of the hospital or long-term care

home for all instances of infection. The ICP also follows up frequently with nursing and other staff (daily, if possible) and occasionally with patients/residents in all areas of the health care setting. Facility-wide surveillance, while comprehensive, requires considerable time and personnel resources. There is no value to identifying infections for surveillance purposes unless the results may be used to effect change that will result in lower HAI rates. Facility-wide surveillance will identify many infections that cannot be prevented, wasting valuable resources that may be used for other purposes, such as education. Prioritization of the types of infections to be surveyed will assist the ICP to make the best use of the available resources while having the greatest impact on the populations that they serve.

Pearl of Wisdom: *Health care settings will not find it feasible to conduct surveillance of all infections in all patients/residents at all times. Prioritization of the most important infections to be included in a surveillance system will be necessary.*

B. GENERAL CONSIDERATIONS FOR SURVEILLANCE CHOICES

The choice of which infections to monitor by surveillance may be determined by several factors:

- Mandatory or required - the health care setting may be mandated to monitor specific infections to comply with provincial reporting, or may be required to monitor infections for accreditation review).[3]
- Incidence - a particular type of infection may be of special concern in the health care setting due to its frequency.
- Communicability - a particular pathogen may be of concern in the health care setting due to its communicability.
- System/patient cost - the infection has associated impacts and costs indicated by:
  - the frequency with which the infection results in mortality (its case-fatality ratio)
  - prolonged hospital stay resulting from the infection
  - issues with transfers to non-hospital settings
  - the excess treatment costs associated with the infection.
- Effectiveness of intervention - surveillance for a particular infection will assess the effectiveness of IPAC interventions.
- Early detection - syndromic surveillance (e.g., acute respiratory Illness or respiratory symptoms indicative of an infectious process, acute gastrointestinal illness) is universally recommended in hospitals and long-term care homes and has the added benefit of detecting important health care-associated infections, such as CDI.

Boxes 4 and 5 illustrate how different types of health care settings may undertake the population assessment and selection of outcomes for surveillance programs.

Box 4: Population Assessment and Selection of Surveillance Outcomes (acute care example)

City General Hospital is a fictitious 550-bed tertiary care facility serving a wide catchment area that includes several surrounding rural communities. City General hospital houses a regional cancer centre and trauma centre and serves some of the region's most critically ill patients. City General Hospital targets high risk patients and undertakes surveillance of all patients in the ICU for two types of device-associated infections:

- ventilator-associated pneumonias
- central venous catheter-associated bloodstream infections.

Total hip and knee replacements, laminectomies and coronary artery bypass grafts (CABG) are among the most common surgical procedures undertaken at City General Hospital. These have been selected for surveillance due to the severe complications associated with surgical site infection following these procedures. Also, with the presence of the cancer centre, colectomies and abdominal hysterectomies have also been selected for surgical site infection surveillance.

With its wide catchment area and the critically ill patient groups that it serves, City General Hospital also tracks the frequencies of both colonization and infection with antibiotic-resistant organisms (AROs).

Box 5: Population Assessment and Selection of Surveillance Outcomes (long-term care example)

Forest Manor is a fictitious 100-bed long-term care home. Half of all residents are dependent on staff for assistance to carry out normal activities associated with daily living.

Symptomatic urinary tract infections (UTIs) comprise one-third of HAIs and 10 per cent of residents have urethral catheters. Lower respiratory tract infections account for half of the remaining HAIs. Approximately 20 per cent of infections developed by residents at Forest Manor are skin and soft tissue infections.

Forest Manor conducts surveillance of lower respiratory tract infections, skin and soft tissue infections and UTIs associated with indwelling catheters. Forest Manor also tracks the percentage of residents receiving annual influenza vaccine to assess how vaccine uptake correlates with lower respiratory tract infections in the resident population.

C. SELECTION OF OUTCOMES IN ACUTE CARE

A *prevalence survey* is a surveillance tool that takes inventory of all active (existing and new) infections at a single point in time. Data from each patient are collected only once, on a single day or over the course of a set number of days.[88-90] Prevalence is useful for measuring the burden of disease in a population, which may in turn inform decisions regarding issues such as the allocation of resources and funding of research initiatives.[91] For example, conducting a prevalence survey of *Clostridium difficile* infection (CDI) in a hospital provides a broad overview of the total number of cases of CDI in the facility and may point to areas in the hospital that require more detailed surveillance or preventive measures.[92]

What tools can be used to assist in selecting the outcomes for surveillance?

Table 1 illustrates a hypothetical set of data on the frequency, impacts, costs and preventability of four common health care-associated infections in a fictional hospital. The data presented in Table 1 can be collected as a first step in surveillance planning through the use of a prevalence survey.

Table 1: Sample hospital dataset used to assist with prioritization of health care-associated infections selected for surveillance

The example data below could be used to frame thinking about the infections selected for monitoring. Surgical site infections constitute a substantial proportion of the HAIs presented here, entail extended duration of hospital stay and increase health care costs. A considerable proportion of these infections are also preventable. The hospital may use the data presented in the table below as a basis for prioritization (or continued prioritization) of surgical site infections in its allocation of surveillance resources through intensive surveillance activities. Also, if a hospital wished to expand its surveillance activities into new areas, the data could be used to identify the infections where surveillance would likely have the most impact.

DATA USED FOR PRIORITIZATION OF HEALTH CARE-ASSOCIATED INFECTION (HAI) SURVEILLANCE IN A FICTIONAL HOSPITAL

Type of Infection	per cent of all HAIs	per cent extra days hospitalized due to infection	per cent extra costs due to infection	per cent of preventable infections
Surgical Site Infection	24	57	42	35
Pneumonia	10	11	39	22
Urinary Tract Infection	42	4	13	33
Bacteraemia	5	4	3	32

A hospital may select its surveillance outcomes based on other factors that are important to the facility. For example, a hospital facing frequent acute care bed shortages may rank infections that result in prolonged hospital stay as an effective allocation of surveillance resources.

Once selected, a hospital's infection outcomes and associated resource allocations in surveillance are not necessarily fixed. For example, based on the data in Table 1, the hospital may choose to not routinely undertake comprehensive surveillance of UTIs, but may still monitor this type of infection through reviews of urine culture test results from laboratory reports, looking for detection of unusual trends or clustering of cases. Changes in the population served by a hospital, the services it offers, or the changing epidemiology of a particular pathogen may change the risk of acquiring specific health care-associated infections and prompt a reassessment of surveillance objectives and a re-allocation of surveillance resources. Surveillance objectives should be re-evaluated as needed, at least annually.

D. SELECTION OF OUTCOMES IN LONG-TERM AND CHRONIC CARE

In long-term care homes, preventable infections may significantly influence the choice of outcomes for surveillance[93, 94]:

- **Acute respiratory infection (ARI)/febrile respiratory infection (FRI):** In long-term care homes, lower respiratory tract infections, such as influenza, are associated with high morbidity, mortality and disruptions to long-term care services.[95] Surveillance for ARI in residents of long-term care homes is universally recommended.

- **Skin and soft tissue infections:** Another important constituent of the burden of health care-associated infections in long-term care homes is skin and soft tissue infections.[39] Many of these infections are preventable, particularly where they result from skin breakdown and pressure ulcer development. Consideration should be given to monitoring skin and soft tissue infections, a common quality of care indicator used in acute, long-term and chronic care settings. Surveillance of skin breakdown provides an opportunity for collaboration of health care providers with the IPAC team to reduce the incidence of soft tissue infections.
- **Urinary tract infection:** In long-term and chronic care settings, many UTIs may be prevented through the limited use of indwelling urinary catheters.[86] These infections contribute significantly to the burden of health care-associated infections in long-term care homes.

Recommended Best Practice #2:

Syndromic surveillance of respiratory infections and gastroenteritis should be undertaken in all hospitals and long-term care homes.

Where hospitals and long-term care homes select outcomes for surveillance in addition to the infections listed above, the following should be considered:

- ***the frequency of the infection***
- ***the impacts of the infection (including per cent case fatality and excess costs associated with the infection)***
- ***the preventability of the infection.***

In both hospitals and long-term care homes, the outcomes selected for surveillance should be re-evaluated at least annually.

3. Use Established Case Definitions for Infection

In any surveillance system, all elements of the data that are being collected need to be clearly defined, including the infection outcome, the '*at risk*' population and other risk factors for infection.[96] This section outlines the recommended best practices for using consistent, standardized case definitions for infection.

A. CASE DEFINITIONS FOR THE HOSPITAL SETTING

The recommendation for hospitals is to use standardized, validated case definitions for surveillance, to allow for comparability.[97] For example, the NHSN program's case definitions are widely used in hospital surveillance programs worldwide[98] and provide benchmarks for comparison. The NHSN case definitions for UTIs, BSIs, pneumonias and other infections are provided in Appendix C.

Best practice recommendation for hospitals is to use one set of case definitions for surveillance purposes. The use of the same definitions allows for comparability of findings and benchmarking with other similar hospitals that use these definitions.[99]

Hospitals may also participate in other surveillance programs, such as the Canadian Nosocomial Infection Surveillance Program (CNISP) [www.phac-aspc.gc.ca/nois-sinp/survprog-eng.php], and use case definitions that have been developed for that program [www.phac-aspc.gc.ca/nois-sinp/projects/index-eng.php].

Benefits to using standardized, validated case definitions include:

- The validity and reliability of the NHSN case definitions have been well established, even for ICPs who are not formally trained in their use.[100, 101] If hospitals choose to develop their own case definitions, they will not have the benefit of using definitions that have been reviewed and validated.

- If a hospital uses its own definitions and at a future date decides to switch to the NHSN definitions, the new data will no longer be comparable to previous rates calculated using the earlier case definitions.
- Hospitals that are similar in size and care level and that use the same case definitions can pool their data to investigate risk factors for infection or practices that may be effective in preventing HAIs.[102] This may be particularly useful when there may be an insufficient number of cases within a single health care setting to provide meaningful results.

Recommended Best Practice #3:

Hospitals should use standardized, validated case definitions for surveillance (Appendix C) and apply the definitions consistently.

Pearl of Wisdom: *Hospitals using established case definitions benefit from:*

- *a set of definitions that have been reviewed and validated; and*
- *surveillance data that can be compared to or pooled with other similar hospitals using the same case definitions.*

Box 6 provides an example of the case definitions chosen by a fictitious hospital.

Box 6: Establishment of Case Definitions (acute care example)

City General Hospital conducts surveillance for primary bloodstream infections associated with the use of central venous catheters (CVC) and for VAP among ICU patients. The NHSN case definitions are used to allow for comparison of findings and benchmarking with other similar hospitals involved in the regional nosocomial infection surveillance program. Patients eligible for this surveillance are adult ICU patients with one or more CVCs and/or patients on ventilator support.

B. CASE DEFINITIONS FOR THE LONG-TERM CARE SETTING

Case definitions were developed by McGeer et al.[93] at a 1991 Canadian Consensus Conference for use in long-term care homes. These definitions were developed taking into account the unique limitations of long-term care surveillance (e.g., lack of radiology and microbiology data). The 1991 definitions have subsequently been reviewed and updated. [94] These case definitions, with revisions, are presented in Appendix D.

While it is recognized that all long-term care homes cannot implement surveillance, recommended best practice is to incorporate the case definitions from Appendix D into surveillance programs in the long-term care setting whenever possible.

Box 7 provides an example of the case definitions chosen by a fictitious long-term care home.

Box 7: Establishment of Case Definitions (long-term care example)

Forest Manor conducts surveillance for UTIs associated with indwelling catheters and uses the recommended case definitions for long-term care homes (see Appendix D), which include only symptomatic infections. Forest Manor also undertakes surveillance for skin and soft tissue infections and lower respiratory tract infections and uses the recommended case definitions for long-term care homes.

Recommended Best Practice #4:

Long-term care homes should use standardized, validated definitions for health care-associated infections in long-term care as provided in Appendix D.

C. APPLYING CASE DEFINITIONS

Once case definitions have been established, steps should be taken to ensure that they are consistently applied. The case in Box 8 illustrates the potential consequences of inconsistently applied case definitions.

D. ENSURING THAT CASE DEFINITIONS ARE CONSISTENTLY APPLIED

Infection Control Professionals should receive training in the consistent and correct application of case definitions for surveillance.[96, 103-105] Periodically, the reliability in application of case definition among ICPs should be assessed. This can be accomplished by having ICPs independently apply case definitions to a set of potential infections. Subsequently the inter-rater reliability, or percentage of cases deemed indicative of infection by both ICPs, can be assessed.[106] See Step 9, "*Evaluate the Surveillance System*" for more information about reliability testing.

Recommended Best Practice #5:

Steps should be taken in hospitals and long-term care homes to ensure that case definitions are consistently and accurately applied.

Box 8: Consequences of Inconsistently Applied Case Definitions for HAIs[107]

In a U.S. community hospital, a surgeon was repeatedly investigated by the hospital's infection control team searching for explanations for an elevated infection rate among patients undergoing laminectomy. The surgeon was prepared to discontinue his practice when strict attention to infection control procedures did not result in a decrease in the rates of infection.

Upon further examination it was found that the surveillance case definition used to collect data on the surgeon's patients included all those who had a positive culture, with or without symptoms of infection. For other surgeons, the case definition required positive cultures plus clinical signs of infection. Hence, patients who were only colonized with bacteria had been included in this surgeon's rate of infection, making it appear high.

The high rates of infection were deemed the result of surveillance error, not of poor operative technique, and the surgeon did not abandon his practice. This case emphasizes the importance of uniform application of case definitions.

Ehrenkranz NJ, Infect Control Hosp Epidemiol 1995

E. DETERMINING IF AN INFECTION WAS ASSOCIATED WITH HEALTH CARE

When a particular infection meets a case definition, it should only be considered nosocomial if it was not present or incubating when the patient/resident was admitted to the hospital or long-term care home. The following considerations may assist in determining if an infection is associated with health care:

- An infection is not considered nosocomial if it represents a complication or extension of an infectious process that was present at admission.
- Infections that occur more than 48 to 72 hours after admission, and within 10 days following discharge, may be considered to be associated with health care. This time interval will depend on the incubation period of the microorganism.
- Molecular typing, if available, may assist in distinguishing circulating strains of a microorganism (e.g., MRSA) in order to assess attribution of a case to the facility or to a particular location within the facility.
- In long-term care homes, in order for an infection to be considered nosocomial:

  There must be no evidence that the infection was present on admission to the facility or readmission (following hospitalization or community visit).

  There must be no evidence that the infection resulted from a procedure performed at an acute care hospital or in a physician's office.

The purpose of the surveillance (e.g., are you trying to monitor the epidemiology of the microorganism or the incidence of infection) will inform the type of surveillance questions that are being asked. For the purpose of mandatory reporting or benchmarking, the definitions that should be used are those that have been established for the type of reporting required.

Determining whether an infection was associated with the care received within the health care setting can represent a major challenge for long-term care homes where residents regularly attend day programs or other activities in the community. When there is uncertainty about whether the infection occurred in community or the long-term care home, the ICP should count a case as "nosocomial" until proven otherwise.

Many bacterial infections typically become apparent within 48 hours following infection.[108] This general timeframe is modified for bacterial or viral infections known to have shorter (e.g., Norovirus) or longer (e.g., hepatitis C) incubation periods. Because the incubation period varies by pathogen and, to some extent, the underlying condition of the patient, it is necessary that each infection be assessed individually for its links to hospitalization or, for long-term care residents, the likelihood that the infection was acquired within the long-term care home.

The most important consideration is that a **consistent** definition for health care-associated infection be used, in order to assess trends over time as part of a facility's internal benchmarking system.[85]

Pearl of Wisdom: *Hospitals and long-term care homes must consider the incubation period for a particular infection and the likelihood that it was acquired in the health care setting when deciding whether a particular case is nosocomial.*

4. Collect the Surveillance Data

The goals and outcomes of the surveillance system and the case definitions established in the previous section will determine the data required by the surveillance program. Health care-associated infections are expressed as a rate, i.e., the number of cases related to the number of persons at risk over a particular period of time. Three elements are required to generate these HAI rates[74, 84]:

- *numerator* - the number of cases (i.e., persons developing a particular infection)
- *denominator* - number of persons at risk (i.e., population at risk for development of that infection)
- the time period involved.

Because health care settings will have differing priorities for surveillance and resources available to them, case finding may vary from facility to facility. The following procedures provide a guide that may be followed when collecting the data required for the surveillance program based on its objectives and available resources[3]:

1. Review and select sources of data/information for the numerator and denominator.
2. Assess the *sensitivity* and *specificity* of the data sources and maximize these two parameters.[96]
3. Choose the most feasible surveillance system for the health care setting.[96]
4. Implement the data collection system.
5. Review the information to ensure the dataset is complete[96] (e.g., ensure that a particular physician or service does not forget to report their cases).

A. REVIEW AND SELECT SOURCES OF DATA/INFORMATION FOR THE NUMERATOR AND DENOMINATOR

The IPAC team should examine the sources of data available to them and select the method(s) of case finding that will provide all of the information required for the case definitions that it has selected for use in its surveillance system. Most established case definitions for health care-associated infections require a combination of both clinical information (i.e., signs and symptoms of an infection) and diagnostic information (e.g., laboratory results, radiological data) on the patient/resident.[94, 109-112]

Table 2: Sources of data/information for numerator data (infection case finding)

Data Source[74, 84]	Methodology	Benefits	Limitations	Resources Required
Total chart/medical record review	▪ ICP reviews medical and nursing notes, medications, treatment records, radiology and laboratory reports for each patient 1-2 times per week for signs of infection (e.g., antibiotics or intravenous fluids ordered, special orders for wound dressing, orders for isolation precautions)	▪ Most complete method of case finding ▪ May be done prospectively or retrospectively	▪ Time consuming (requires 10-30 minutes per record) ▪ Unable to identify all infections due to: ○ Missing data, diagnostic reports ○ Record unavailable at time of review ○ May be difficult to confirm that criteria for infection have been met	▪ Additional ICP resources may be required
Laboratory reports	▪ ICP reviews daily laboratory reports for positive culture results that prompt investigation of potential HAIs ▪ Significant results 'flagged' in electronically-generated batch reports ▪ Laboratory staff notify ICP with significant results	▪ Quickly identifies significant increases in some types of infections ▪ Often identifies microorganisms of special concern before any other method (e.g., MRSA) ▪ ICPs who visit the laboratory will develop rapport with staff, leading to better cooperation and understanding of each other's roles	▪ Infections are missed if cultures are not sent or if microorganisms fail to grow on culture media ▪ Infections are missed if diagnosis is based on signs and symptoms alone. ▪ False-positive infections if laboratory-based surveillance is used alone (patient may only be colonized e.g., MRSA)	▪ Electronic laboratory information system beneficial ▪ ICPs must work closely with the laboratory that services their hospital to develop reporting mechanisms from the laboratory to the ICP
Nursing Kardex/Patient Profile	▪ ICP reviews nursing Kardex/patient profile for each patient 1-2 times per week for signs of infection (e.g., temperature charts, intravenous fluids, antibiotics given, application of Additional Precautions)	▪ Prospective surveillance ▪ Quickly identifies patients suspected of having an infection that require a more detailed review ▪ May identify early signs/ symptoms indicative of an outbreak	▪ Relies on accuracy and completeness of the Kardex/Patient Profile for information ▪ Information must be confirmed with a review of the medical record	
Clinical ward/unit rounds	▪ ICP joins patient care staff during clinical rounds, entering into discussions and information sharing regarding	▪ Prospective surveillance ▪ Increases ICP visibility in patient care areas	▪ Time-consuming	▪ Additional ICP resources may be required

Data Source[74, 84]	Methodology	Benefits	Limitations	Resources Required
	potential infections that may not be included in patient records until a definitive diagnosis has been made.	▪ Provides ICP with opportunities to monitor patient care practices ▪ Provides opportunity for discussion and informal education on infection prevention and control issues ▪ May hasten the application of Additional Precautions when communicable infections are suspected		
Sentinel reporting system	▪ Patient care staff complete forms documenting possible indicators of infection (e.g., fever, symptoms of respiratory infection, unexplained GI illness). ▪ Patient care staff complete and provide these forms on a routine, often daily, basis	▪ Prospective surveillance ▪ Provides an alert system for outbreaks ▪ Refer to Appendix E for a sample sentinel surveillance form for completion by ward/unit staff	▪ Relies on ward/unit staff taking time to complete forms ▪ Relies on accuracy of ward/unit staff in completing foms	▪ May require additional ward/unit resources
Electronic screening of patient records	▪ Case finding via searches of medical record databases (‘*data mining*’) is an emerging tool for surveillance ▪ Patient records are flagged via algorithm for indicators of HAI	▪ Effective means to identify post-discharge surgical site infections[113] ▪ Uses include surgical site infections, UTIs and CVC-associated bloodstream infections[114-116]	▪ Results must be verified for accuracy ▪ Relies on accuracy of information that has been entered into the electronic database	▪ Require sophisticated electronic information systems with the ability to create specialized searches and access of ICPs to results

Numerator Data Collection in Hospitals

What sources of data are available for case finding in hospitals?

Sources of data that are commonly used for case finding in the acute care setting with their associated benefits and limitations are presented in Table 2.

Numerator Data Collection in Long-Term Care Settings

What sources of data are available for case finding in long-term care homes?

The wide range of sources of information that are available in acute care to identify infections is not typically available in the long-term care setting (e.g., regular laboratory reporting, nursing Kardex/patient profile). As a result, case finding in long-term care settings will rely more heavily on feedback from those directly involved in resident care.

Sources of data that are commonly used for case finding in the long-term care setting include:

- regular ward visits by the ICP
- sentinel surveillance sheets, completed by staff on the wards and collected regularly (these provide an excellent mechanism for feedback from the staff regarding potential infections).

Pearl of Wisdom: *Don't forget the denominator!*

Collecting Information for the Denominator

A surveillance rate includes the number of cases (numerator) identified in the population at risk (denominator). Therefore, a surveillance system must be able to collect data on the overall population at risk for acquiring health care-associated infections, as well as the individual patients/residents who actually acquire the disease.

For example, for device-associated infections, the population at risk includes the total number of patients/residents exposed to a particular device (e.g., ventilator, central venous catheter, indwelling urinary catheter)[117] during the time period selected for surveillance (e.g., month, quarter). For surgical site infections, the population at risk includes all patients who had the same operative procedure. Additional guidance on rate calculation is provided in Step V, "*Calculate and Analyze Surveillance Rates*".

B. ASSESS THE SENSITIVITY AND SPECIFICITY OF SOURCES OF SURVEILLANCE DATA

A surveillance program should consider two evaluative criteria applicable to any case finding method: sensitivity and specificity.

a) *Sensitivity* of a case finding method describes its ability to correctly include infections that are present (i.e., the number of true positive infections detected by a case finding method divided by the number of true positive infections + false negative infections detected by the case finding method).

b) *Specificity* of a case finding method describes its ability to correctly exclude infections that are not present (i.e., the number of true negative infections detected by a case finding method divided by the number of true negative infections + false positive infections detected by the case finding method).

Using 2 x 2 Tables to Calculate Sensitivity and Specificity

	Infection	No infection
Meets case definition	*a*	*b*
Does not meet case definition	*c*	*d*

$$\text{Sensitivity} = \frac{a \text{ (numerator)}}{a + c \text{ (denominator)}} \qquad \text{Specificity} = \frac{d}{b + d}$$

Where:

a = true positive infection
b = false positive infection
c = false negative infection
d = true negative infection

The following example may be used to illustrate ways to calculate the sensitivity and specificity of a case definition:

Example: On a special care unit with 11 ventilated patients, 3 patients have a ventilator-associated pneumonia (VAP). Only two of the three patients meet the case definition for VAP that the ICP has developed, but two patients without a VAP also meet the case definition. The sensitivity and specificity of the case finding method may be illustrated with a 2 x 2 table in this way:

	VAP	No VAP
Meets case definition	2	2
Does not meet case definition	1	6

$$\text{Sensitivity} = \frac{\text{\# true positives}}{\text{(\# true positives + \# false negatives)}} = \frac{2}{3} = 0.67$$

$$\text{Specificity} = \frac{\text{\# true negatives}}{\text{(\# true negatives + \# false positives)}} = \frac{6}{8} = 0.75$$

Figure 2 illustrates a way to demonstrate the assessment of sensitivity and specificity for the above example.

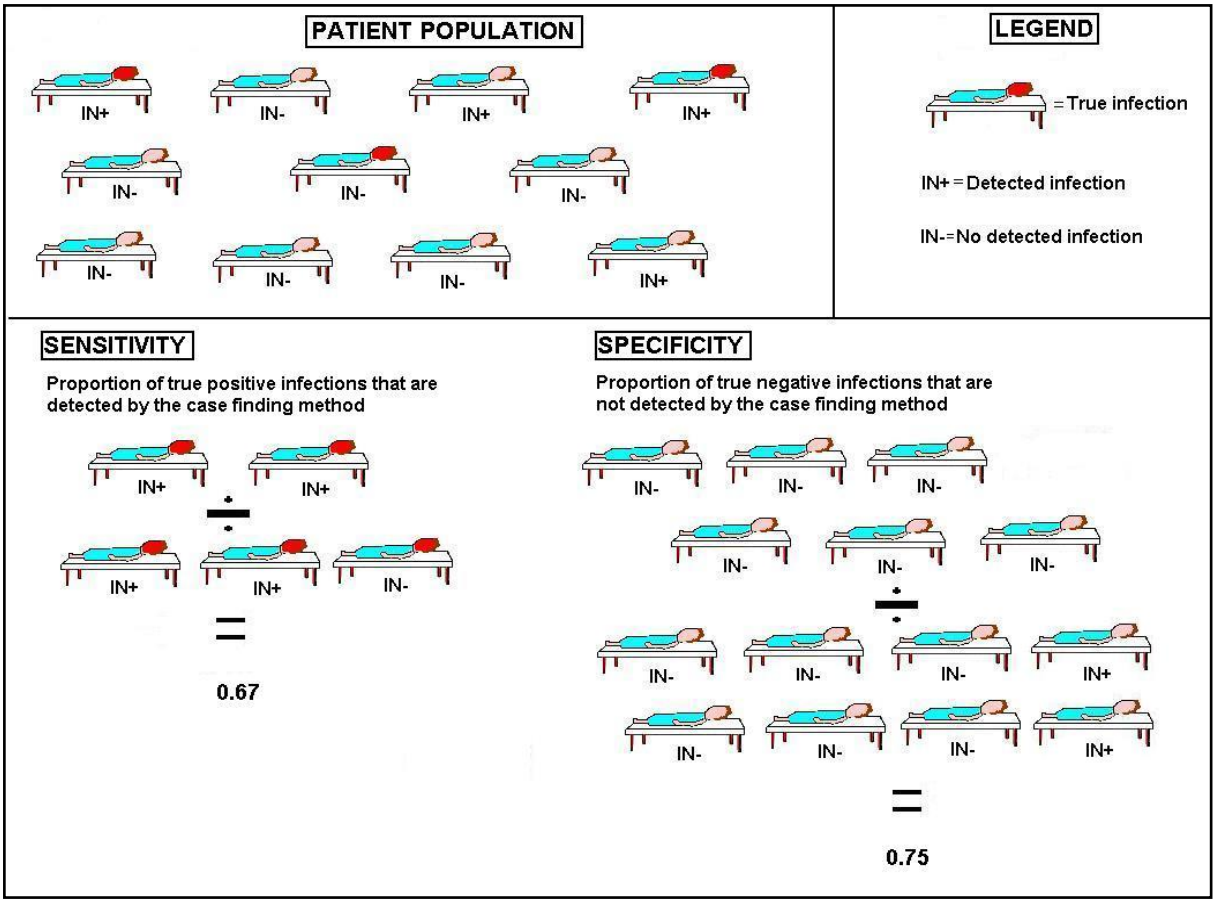


Figure 2: Calculating sensitivity and specificity of sources of surveillance data

Ideally, a case finding method will have both a high sensitivity and specificity, i.e., it is able to detect a high percentage of all infections, while at the same time identifying only cases with a high likelihood of actual infection. A relatively high specificity is desirable so that the time that an ICP spends confirming an infection is minimized.

Table 3 summarizes the sensitivity and specificity of total chart review relative to other sources of data for case finding. The ICP resources required for each of these case finding methods are also shown in this table. Table 3 demonstrates that similar or higher levels of sensitivity for case detection can be obtained through less resource-intensive case finding methods when compared to total chart review.

Once the data sources that are available to the health care setting have been identified, the sources should be ranked according to their estimated sensitivity (see Table 3). Final selection of data sources to be used for each type of infection that is surveyed will be based on those that have the highest sensitivity and specificity and that are the most feasible to implement in the health care setting.

Table 3: Sensitivity of Various Case Finding Methods and Associated ICP Resources Required for Implementation in Acute Care

Rank (based on sensitivity of method to detect cases)	Case Finding Method	Definition	Estimated ICP Time (hours) / Week / 500 Beds*
(most sensitive) 1	Electronic Case Finding[118]	Automated detection of nosocomial infections using combined microbiology laboratory data and antibiotic prescription data from electronic hospital information systems	Not specified
2	Laboratory Reports	Microbiology reports to identify patients with positive cultures	23.2
3	Kardex Screening	Patient Kardex to determine patients at high risk for infection	14.3-22.3
4	Laboratory-based Ward Liaison Surveillance	Microbiology reports to identify patients with a positive culture and patients reported by nursing staff to have an infection	31.8
5	Total Chart Review	Review all patient medical records	35.7-53.6
6	Infection Control Sentinel Sheet System	"Sentinel Sheet" to identify patients reported by nursing staff to have symptoms of infection	Not specified
7	Fever and Antibiotic Use	Temperature record to identify patients with fever >37.8 C, and medication record to identify patients receiving antibiotics	13.4
8	Ward Liaison Surveillance	Patients reported by nursing staff to have an infection	17.6
9	Antibiotic Use	Medication record to identify patients receiving antibiotics	14.3
10	Risk Factor Based Surveillance	Nursing reports and medication records to identify patients with risk factors for infection	32.4
11	Fever	Temperature record to identify patients with temperature > 37.8 C	8
12	Readmission	Admission record for patients readmitted with infection	Not specified
13 (least sensitive)	Autopsy Reports	Autopsy reports to identify patients with infections	< 0.53

* Number of hours per week required for an infection control professional to perform surveillance in a 500-bed hospital

[Source: Pottinger, Herwaldt, & Perl, 1998[119]]

C. CHOOSE THE MOST FEASIBLE SURVEILLANCE SYSTEM FOR THE HEALTH CARE SETTING

The approach to case finding should satisfy all information requirements of the surveillance program, while at the same time be feasible in the context of the IPAC program's resources.

The surveillance system or approach that will be used in the health care setting must be determined and a decision made as to whether it will be involved in *active* or *passive* surveillance.

Active surveillance involves actively seeking out health care-associated infections on a regular basis by individuals trained in surveillance, usually ICPs:

- ICP seeks out possible health care-associated infections on a regular basis (e.g., several times per week) using a variety of data sources.
- ICP determines whether an infection meets the criteria for a health care-associated infection based on the standardized case definitions.
- Active surveillance requires a high level of ICP effort and resources to be effective.

Passive surveillance involves reliance on staff to provide infection information to the ICP:

- Patient/resident care staff report infections or suspected infections to the ICP.
- Passive surveillance requires the least amount of ICP time and resources but is the least sensitive system.

Figure 3 illustrates that the sensitivity associated with active and passive surveillance is directly proportional to the intensity of the surveillance activities involved.

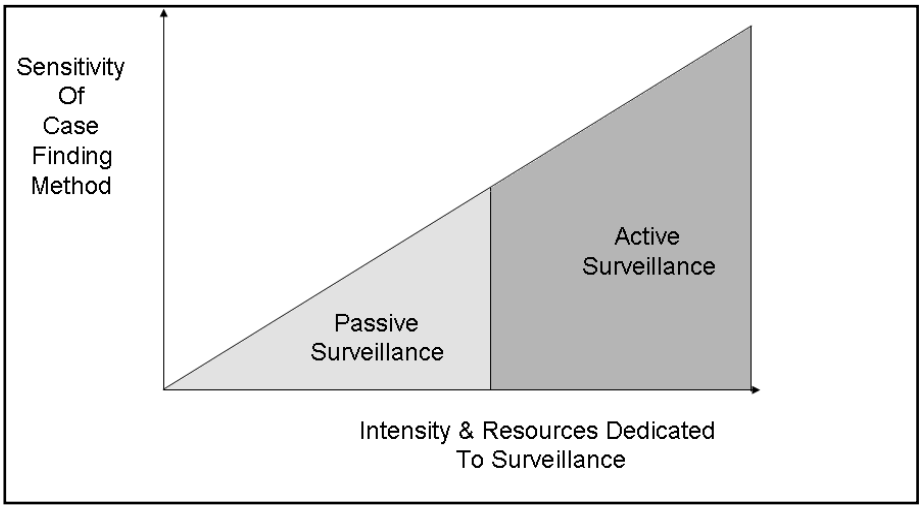


Figure 3: Intensity of resources associated with active and passive surveillance

Passive surveillance systems may be associated with higher levels of misclassification and underreporting of health care-associated infections because they rely on information provided from staff whose responsibilities are centered on patient/resident care and who are less familiar with the application of case definitions. These staff may not have time to keep abreast of changes in surveillance procedures, surveillance definitions or clues to infection beyond the ward/unit on which they provide care. As a result, passive surveillance systems may not provide high quality data or timely information on changes in the risk of health care-associated infections. [169, 170]

Active surveillance is associated with a higher level of sensitivity and is recommended for case finding.[120, 121] Passive surveillance might, however, be the only feasible approach to case finding due to resource constraints. If this is the case, it is critical that education and training is undertaken for patient/resident care staff to ensure that potential infections are identified and that reporting expectations are met.

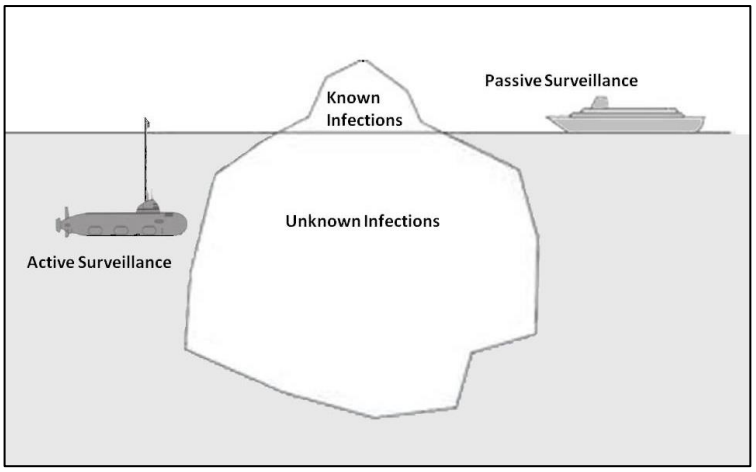


Figure 4: 'Tip of the Iceberg': Passive surveillance vs. active surveillance

Recommended Best Practice #6:

Active surveillance should be used in hospitals and long-term care homes because of the higher sensitivity associated with this approach to case finding.

D. IMPLEMENT THE DATA COLLECTION SYSTEM

The range of information source(s) used to screen for HAIs can assist in establishing the thoroughness of a case finding method. Health care settings that draw on a wide range of sources for information will detect a greater number of infections.[122, 123]

Electronic Information Systems

Facility-wide Medical Information Systems

Computerized medical information systems that are already well-established in hospitals and in many long-term care homes evolve over time; they are improved based on new technology and refined to better address the needs of the user.[124] On an ongoing basis, computer systems benefit from the participation of ICPs to ensure that the necessary structures and fields for electronic screening for HAIs are practical and reflect current best practice. ICPs should work with their facility information technology (IT) department to determine how they may obtain electronic information from the facility's information system.

The following inclusions to the electronic patient record will assist in identifying potential health care-associated infections[91]:

- positive laboratory cultures[99, 118]
- imaging results
- details of antibiotic use from the hospital pharmacy[105, 118]
- presence of a medical device[125]
- nursing progress reports[125]
- details regarding surgical procedures.[99]

IPAC-specific Information Systems and Programs

Using computerized IPAC-specific electronic programs and information systems to collate and evaluate HAI information has the benefit of decreasing the amount of time spent on data analysis and report

generation. Case finding via computer algorithm may result in more of the ICP's time being devoted to prevention,[126, 127] for example, using a computer generated report to limit the number of cases that would be followed by an ICP to those with a high likelihood of infection.[128]

In some cases, however, ICPs with a qualified electronic surveillance system reported no difference in time spent on data collection and entry, reporting, or education and process improvements compared with facilities performing manual surveillance. One explanation is that facilities with a qualified electronic surveillance system might be identifying more infections and patterns, and so the efficiency gained is offset by the increase in data that must be managed. Additionally, learning to navigate a new system to complete formerly routine tasks might increase the amount of time spent on these types of tasks.[102]

Electronic Screening

While electronic screening of patient/resident records has the potential to increase the efficiency of case finding, caution is advised in the use of this tool. General '*data mining*' can be an oversensitive tool,[102, 105] resulting in investigation of an excessive number of flagged patients/residents that do not meet the case definitions for infection. Electronic screening may also miss cases.[121, 129]

Very clear indicators for infection should be incorporated into the search mechanism when setting up a system of electronic screening for infection.[130] For instance, some electronic screening systems for post-discharge surgical site infections have been able to flag cases by placing certain dosage and duration parameters on antibiotics as an indicator for infection in order to separate therapeutic from prophylactic treatments. Incorporation of threshold limits into the electronic screening process is an additional tool that will assist the ICP by indicating when there is an increase above the facility's baseline rate of infection.

Mechanisms are required to ensure ongoing data integrity. For example, if an electronic data source changes terminology or adds new kinds of data, there must be a way to ensure that the database receiving the information handles it appropriately.[91]

Once the surveillance system has been defined in terms of its case definitions, sources of data and method of data collection, the data that is being received must be "*cleaned*" or assessed for accuracy and validity. Further investigation of cases that were initially identified as infections requires full chart review and follow-up with patient/resident care staff. This will exclude cases that do not meet the case definition for infection.

The process for identifying potential infections that require further follow up is illustrated in Figure 5.

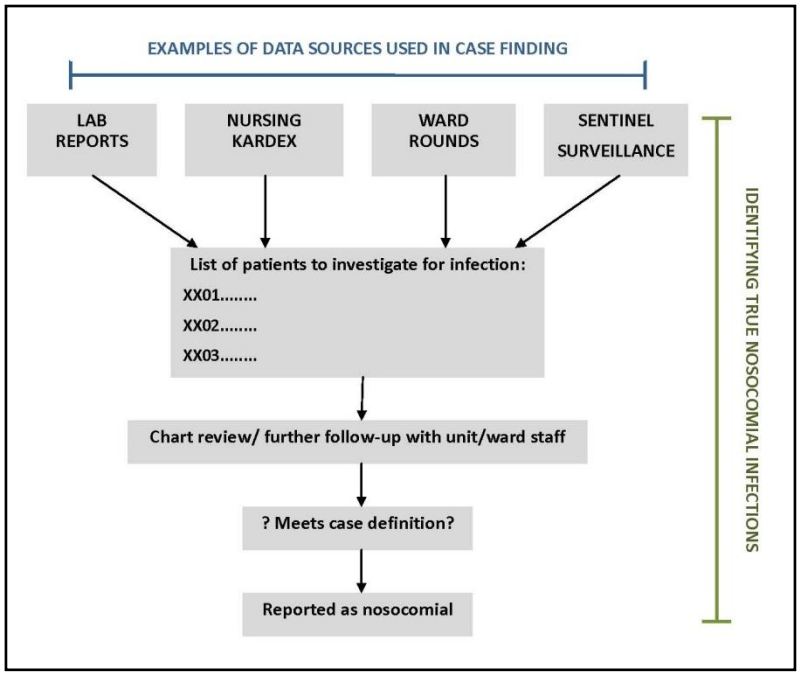


Figure 5: Identification and follow-up of potential health care-associated infections

Pearl of Wisdom: *Total chart review is not recommended as a case finding method in acute care settings due to the significant time required to obtain data. Different sources of information should be strategically combined to quickly identify potential infections, then further investigation and follow-up is conducted to confirm infection through total chart review and/or consultation with physicians.*

Boxes 9 and 10 present examples of case finding and data collection in a hospital and a long-term care home.

Box 9: Case Finding and Data Collection (acute care example)

- *The ICPs at City General Hospital conduct active surveillance. Each ICP is responsible for undertaking surveillance in a particular patient care area.*
- *To identify HAIs, the ICPs first undertake a daily review of hospital laboratory reports to identify positive culture results that might indicate infection.*
- *From this laboratory report, the ICP formulates a list of potential infections in his/her assigned patient care area.*
- *The ICP then visits the nursing units for follow-up of the positive cultures and for identification of additional potential infections through discussions with unit nurses and notes on patient profiles ('Kardexes').*
- *From these data sources, the ICP develops a full list of potential infections to be confirmed through more detailed chart review and consultation with clinicians.*
- *The form below assists the ICP in organizing the information collected:*

Potential infections for investigation

Date: _____ Patient care area:_____

Patient ID	Source of data (check all that apply)				Indication of possible infection (e.g., + cultures, fever, antibiotics, new orders for precautions)	Findings from chart review	Findings from discussion with patient care staff
	Lab Cultures	Ward Rounds	Kardex	Sentinel sheet			
001							
002							
…							

- *For surveillance of device-associated infections (e.g., CLABSI, VAP), the ICP obtains denominator data (the number of patients exposed to procedures and devices) from the ICU's specialized database.*
- *For surgical site infections, denominator data (total number of patients undergoing the selected surgical procedure) is obtained from the City General Hospital's surgical database.*

Box 10: Case Finding and Data Collection (long-term care example)

- *At Forest Manor, ward nurses complete a form designed by the ICP during each shift, identifying the residents with signs and symptoms of UTI, skin or soft tissue infections, or of lower respiratory tract infections.*
- *The total number of residents with indwelling urinary catheters on a ward is also recorded on the form by nursing staff, so that denominator data can be compiled.*
- *The form shown below is an example that assists the ICP with data collection:*

Infection Control Daily Rounds Date: _____ Ward/unit:_____

No. Residents on Ward/unit: _____

Completed by:_____

Patient ID	Residents in ward showing signs and symptoms of lower respiratory infection? (e.g., fever + malaise, sore throat, cough)	Residents on ward showing signs and symptoms of skin/soft tissue infection? (e.g., pus/drainage from wound site, fever + inflammation or soreness at site)	Resident has an indwelling catheter?	Catheterized residents on ward showing signs and symptoms of urinary tract infections? (e.g., change in character of urine and other symptoms of infection)	Outline actions undertaken for any suspected infections (e.g., laboratory tests ordered, precautions)
001					
002					
...					

- *The ICP follows up these residents, discusses them with the ward nurses and applies the pre-established case definitions with laboratory findings in order to classify the case as a confirmed infection, a suspect infection or infection ruled out.*

E. REVIEW THE INFORMATION TO ENSURE THE DATASET IS COMPLETE

One of the challenges with any surveillance system is incomplete data reporting. [171] For example:

- Surgeons may not realize that they are to report surgical site infections seen in the outpatient clinic.
- Staff in an intensive care unit (ICU) may be fully occupied with urgent patient care needs and not complete surveillance forms in a timely fashion.

These challenges generally occur over time, after the initial enthusiasm or novelty of the surveillance system wears off. Methods for regularly reviewing the surveillance system to ensure quality include:

- audits of the surveillance system to ensure that all data items are being collected and that the dataset is complete
- assessment of the timeliness of case documentation by calculating the time from onset of infections to the time when they are entered into the surveillance dataset.

Regular reporting of surveillance information back to the providers of the information (e.g., surgeons in their clinics, staff in ICUs) provides feedback, reminds them of the importance of reporting to the system and allows them to see the results of their input and give the IPAC team comments if they do not understand the results.[46, 83]

Post-discharge surveillance for surgical site infections

Surveillance for surgical site infections (SSIs) should be a key component of a hospital's surveillance system given the severity, high cost[19, 131, 132]and frequency of these preventable infections. With a rapidly increasing trend towards shorter stays and an increasing proportion of surgeries performed in an outpatient setting, the frequency of SSIs becoming apparent post-discharge has inevitably increased.

The percentage of SSIs that develop post-discharge has been estimated at around 50 per cent in several studies,[133-135] but has been reported as high as 80-89 per cent.[123, 136, 137] An effective surveillance system should include strategies to detect SSIs that develop post-discharge.[122, 135, 138-140]

All patients who are included in the denominator should have follow-up completed. Post-discharge surveillance generally involves follow-up with patients or surgeons within a one-month period post-discharge, often via questionnaire or over the telephone, in order to identify potential surgical site infections. However, patient groups have been shown to be unable to recognize SSIs, even when given specific verbal and written instructions.[141] Follow-up both with patients and surgeons for SSIs post-discharge is frequently associated with low response rates.[137] As surgical patients at high risk for infection are less likely to be lost to follow-up, HAI rates might appear to be lower than they would be if results from low risk patients (who were lost to follow-up) were included.

To date there is no generally accepted method for conducting post-discharge surveillance for SSIs outside the hospital setting and no formal recommendation on post-discharge surveillance methodology is possible. There is little evidence on which to base recommendations for one particular case finding method for post-discharge SSIs over another. A review of the literature by Kent et al.[142] found the following factors to be associated with higher response rates to questionnaires sent to surgeons for information on post-discharge SSIs:

- a well-defined geographical region
- voluntary collaboration of surgeons and cooperation extending to case managers, secretaries and surgical receptionists
- an enthusiastic and persistent ICP
- frequent personal contact by the ICP and other members of the Hospital Epidemiology/Infection Control Committee
- 'user-friendly' data collection sheets (brightly coloured forms with case definitions printed on the back)
- a reliable free courier service for pick up and delivery of surgeon's letters and completed questionnaires
- tracking and reminders regarding unreturned questionnaires
- feedback provided to all involved, including results posted in surgeons' lounge and at departmental meetings
- second and third phone calls if the data was not received within the agreed time frame.

Many of these factors require considerable additional time and resources by the Infection Control Team. ICPs are encouraged to develop innovative approaches for the detection of post-discharge SSIs that do not interfere with the time spent on other components of their surveillance system. Examples include:

- partnering with organizations providing home care services to surgical patients to ensure that post-discharge SSIs that develop in their clients are promptly reported to the hospital's ICP[143]
- electronic screening of patient's records post-discharge for indications of infection (e.g., return visits to emergency department)[113, 142]
- readmission flags on hospital databases to detect admission due to infection.[144]

5. Calculate and Analyze Surveillance Rates

The steps in data collection described to this point have been focused at the level of the individual patient/resident. Calculating incidence rates involves compiling individual level patient/resident data and then aggregating it into a summary of the risk for developing a HAI within a population of patients over a specified time period.

Incidence rates are population-level measures where the *numerator* is the infection or event of interest and the *denominator* includes the group of persons in which the infection or event may occur during the time frame of interest, i.e., population at risk for HAI. A summary sheet on the calculation of surveillance rates is provided in Appendix F.

A. SURVEILLANCE RATES ADJUSTED FOR LENGTH OF STAY

In many health care settings, overall HAI rates are calculated by dividing the number of health care-associated infections identified over a given time period (e.g., per month) by the total number of admissions or discharges in the month. However, overall facility HAI rates may be misleading[85]:

- patients may be at varying risk of infection because of varying length of stay in a facility
- the longer a patient is in hospital the greater the likelihood of acquiring infection.

For example, obstetric ward patients typically have short stays and generally have a lesser risk of developing a HAI. In contrast, ICUs or rehabilitation wards generally have fewer admissions but patients on these wards have longer stays and are at a higher risk of developing a HAI. If the rate of infection was expressed as the number of cases divided by the number of admissions per month, it would likely underestimate the risk of infection on a high turnover, low risk obstetrics ward (because the denominator is inflated) and overestimate it on a low patient turnover, high risk ICU or rehabilitation ward.

Health care-associated infection rates should be adjusted for length of stay, i.e., the number of infections per patient/resident day, in hospitals and long-term care homes. Rates of infection per patient/resident day, also called *incidence density rates*, provide a more accurate estimate of the risk of infection in a particular health care setting.

Incidence Density Infection Rates	
What are they?	A rate of infection that adjusts for time at risk for HAI, in this case, length of hospital stay.
How are they calculated?	By dividing the total number of infections detected by the total number of days that patients spent in hospital over a surveillance period.
What information do they convey?	The risk of HAI over a particular time period, taking into account varying lengths of stay in hospital by patient.

In some areas of long-term care, such as long-term care homes, resident turnover is generally low, particularly in self- care areas. The resident population is generally fixed and the denominator is relatively constant with the same number of residents contributing the same number of resident days. Adjustment for resident length of stay may not be critical in this context.

However, other areas of long-term care, such as units providing Complex Continuing Care (CCC), will have higher numbers of resident transfers and thus a varying denominator.

The total number of resident days over a given surveillance period is often readily available from a facility's billing department and can be used to calculate a rate of infection expressed in terms of

resident days. It is recommended that rates of health care-associated infection be expressed per resident day in order to account for resident transfers in and out of long-term care homes, allowing for more accurate rate comparisons.[145]

Recommended Best Practice #7:

Rates of health care-associated infection for patient/resident length of stay should be adjusted by using the number of patient/resident days as the denominator, rather than number of admissions or number of beds.

B. SURVEILLANCE RATES ADJUSTED FOR TYPE OF PROCEDURE IN THE HOSPITAL SETTING

Hospital patients are at varying risk for HAIs depending on the therapeutic interventions that they undergo in acute care.[146] For example, patients undergoing knee arthroscopy are at a lesser risk for surgical site infection than those undergoing colon surgery or coronary artery bypass graft (CABG). These differences in infection risk are due to:

- the invasiveness of the procedure
- the characteristics of the patients undergoing the procedure.

One way to control for different risks associated with different surgical procedures is to compare patients having undergone the same surgical procedure. The numerator consists of the number of patients having developed a SSI following a specific surgical procedure and the denominator consists of all patients having undergone that same surgical procedure during the same period of time (e.g., in a particular month).

Procedure-specific Surgical Site Infection Rates	
What are they?	A rate of surgical site infection (SSI) specific to an operative procedure.
How are they calculated?	Divide the total number of surgical site infections that occur during a specific time period following a specific operative procedure by the total number of persons undergoing that operative procedure during that same time period.
What information do they convey?	The risk of SSI associated with a specific type of operative procedure in a hospital in a given period of time. The risk of SSI varies according to the operative procedure. Therefore, calculating a rate of infection that is specific to an operative procedure provides a means to control for risks associated with different operative procedures.

Operative procedure categories or procedural codes may be based on Canadian systems (*International statistical classification of diseases and related health problems. Tenth revision*[147], available online at: http://apps.who.int/classifications/icd10/browse/2010/en) or on U.S. systems (*International Classification of Disease, 9th Revision – Clinical Modification, Volume 3 (Procedures*)[148]) that have been developed by the U.S. National Center for Health Statistics (available online at: www.cdc.gov/nhsn/PDFs/OperativeProcedures.pdf) These may be used to assist in grouping similar surgical procedures. A list is provided in Appendix G.

Recommended Best Practice #8:

Rates of surgical site infection in patients undergoing the same surgical procedure should be calculated. Strategies should also be developed to detect surgical site infections post-discharge. There is no generally accepted method for conducting post-discharge surveillance outside the hospital setting.

C. SURVEILLANCE RATES ADJUSTED FOR EXPOSURE TO MEDICAL DEVICES

Exposure to medical devices, such as ventilators, CVCs, intravenous catheters, enteral tubes and indwelling urinary catheters, is associated with a higher risk of HAI. The longer a patient/resident is exposed to a device, the greater their likelihood of developing an infection. Adjustment for exposure to medical devices is important in both hospitals and long-term care settings.[117] With a growing population receiving complex continuing care, exposure to medical devices such as CVCs (e.g., for dialysis treatments, supportive care) is increasing outside of the hospital setting. In addition, the percentage of long-term care residents with indwelling urinary catheters can exceed 10 per cent.[145]

To obtain a rate that is adjusted for length of exposure to a device, divide the number of device-associated infections by the total number of days that all patients/residents were exposed to the device during the surveillance period. For example:

- A surveillance program monitoring ventilator-associated pneumonias (VAPs) among ICU patients would calculate the rate of infection by dividing the number of VAPs in ICU patients by the total number of days during which ICU patients were ventilated during the surveillance period (e.g., monthly).

In the Know...Ventilator-associated events (VAE)

Previous definitions for ventilator-associated pneumonia (VAP) were based on a combination of criteria that lacked specificity for VAP, were often based on documentation that varied from person-to-person, and were highly subjective, resulting in VAP rates that did not capture the true incidence of VAP.

In 2011 the NHSN modified the definition, using a tiered approach based on both objective criteria about ventilation and clinical evidence of infection. The new definition is known as a ventilator-associated event (VAE).[111] See Appendix C for more information.

- The complex continuing care (CCC) unit of a long-term care home monitoring CLABSIs would divide the number of primary BSI in CCC patients/residents by the total number of days during which CCC patients/residents had a CVC in place during the surveillance period (e.g., quarterly).

Device-associated Infection Rates	
What are they?	A rate of infection associated with exposure to a medical device, such as a ventilator, central venous catheter or indwelling urinary catheter.
How are they calculated?	By dividing the total number of infections experienced by patients/residents exposed to a particular device by the total number of days that all patients/residents were exposed to the same device.
What information do they convey?	The risk of health care-associated infection associated with exposure to a particular device over a particular time period, taking into account varying lengths of time that patients were exposed to that device.

Recommended Best Practice #9:

Rates of device-associated infection that are adjusted for duration of exposure to the device should be calculated.

Denominator data for device-associated infections

Obtaining data on the total number of patients/residents at risk for device-associated infection may present a challenge for some health care settings.[117] For example, if the ICP is surveying the rate of UTIs associated with indwelling urinary catheters among those over age 65, only the total number of catheter-days will be available using this method of data collection. The number of catheter-days in the over 65 age group cannot be separated from this total for use in the denominator; hence the rate in this age group cannot be calculated.

In some hospitals, special care areas (e.g., the ICU) may maintain their own database on patients where the number of days that a particular patient was exposed to a device is included or can be included as part of data collection. Where device-days are not routinely collected within a patient/resident population, surveillance systems must rely on other means for obtaining this data.

What tools can be used for collecting denominator data for device-associated infection rates?

Some hospitals and long-term care homes have arranged for health care providers to complete an index card outlining the date that a patient started on a device and the date that this exposure ended. These completed cards can be routinely picked up by the ICP.

Another method for collecting information about device-days is to have staff count the total number of patients/residents who are exposed to the device of interest each day and report these figures to the ICP. While this approach will provide the total number of device-days required for the denominator, it does not provide information on how long each patient/resident was exposed to a device.

Figure 6 illustrates a sample card that may be used by staff for the collection of device-days for CLABSI rates.

Obtaining the length of time that each patient/resident is exposed to a particular device, rather than the total number of device-days for a patient care area, is ideally recommended as part of data collection for calculating device-associated infection rates. In addition, if a patient/resident has multiple concurrent devices (e.g., more than one CVC at a time), device days should be calculated as the sum of each individual device day.[83, 117] For example, if a patient has a subclavian catheter in place for 8 days and a jugular catheter in place for 4 days at the same time as the subclavian catheter, the total number of CVC days is 12.

CVC-associated BSI? **YES __** **NO __**

Last Name: _____ First Name: _____

HFN _____

Date of Admission: _____ Date of Discharge: _____

Number of Days on Ward/Unit: _____

Central Venous Catheter (CVC) inserted on this ward/unit? YES __ NO (Ward/Unit: _____)

Date first inserted: _____Type: _____

Dates changed:

Date: _____ Type: _____

Date: _____ Type: _____

Date: _____ Type: _____

Date: _____ Type: _____

# of positive blood cultures: ____ # taken: ____

CULTURES: **SYMPTOMS:**

Date	Site	Organism	Date	Temp	WBCs	BP	Other:

Figure 6: Sample card for collection of device-days for CLABSI denominator

Recommended Best Practice #10:

When collecting data for the denominator for device-associated infection rates, data should be collected on the length of time that each patient/resident was exposed to a particular device, rather than the total number of days that all patients were exposed to the device.

Boxes 11 to 14 provide example data sets and calculation of incidence HAI rates for AROs and HAI rates adjusted for exposure to procedures and devices in the fictional hospital and long-term care home.

Box 11: Calculation of Incidence Density of Device-associated Infection (acute care example)

- *The Infection Control Team at City General Hospital calculates the following infection rates over the quarterly surveillance period. The ICP obtains data on exposure to central lines and ventilators for each patient from the ICU database. These data are demonstrated in the following spreadsheet:*

Patient ID	Date of central line insertion	Date of central line removal	Date of primary bloodstream infection	# of days with central line	Date patient went on ventilator	Date patient was taken off ventilator	Date of onset of pneumonia	# days on ventilator
0001	Jan 21	Feb 7	No infection	14	.	.	No infection	0
0002	Jan 28	March 2	Feb 28	32	.	.	No infection	0
0003	.	.	.	.	Jan 2	Jan 11	Jan 9	10
0004	Feb 1	Feb 13	No infection	12	Jan 15	Jan 31	No infection	15
0005	.	.	.	.	Feb 3	March 4	Feb 25	28
.		.	.	.	.	.	.	.
.		.	.	.	.	.	.	.
0080	March 7	March 30	March 30	22	.	.	No infection	10
Total for first quarter:			**8 infections**	**1,080 line-days**			**4 total infections**	**660 ventilator-days**

- *In order to calculate the rates of central-line associated bloodstream infections and ventilator associated-pneumonias, the ICP totals the columns in the spreadsheet above and divides the number of infections by the total number of device-days. Rates of HAI during the surveillance period are shown below:*

Infection outcome	Number of events (numerator data)	Population at risk (denominator data)	Rate of infection
Central line- associated blood stream infection	Primary bloodstream infections among ICU patients on central lines: 8	Total number of days that ICU patients were on central lines over year period: 1,080	Rate of bloodstream infection: = No. events No. of central line-days X 1,000 = 8 1,080 X 1,000 = 7.4 per 1,000 central line-days
Ventilator-associated pneumonia	Pneumonias developing in ventilated patients: 4	Total number of days that ICU patients were on ventilators: 660	Rate of pneumonia: No. events no. of ventilator-days X 1,000 = 4 660 X 1,000 = 6.1 per 1,000 ventilator-days

Box 12: Calculation of Incidence of Surgical Site Infection (acute care example)

- *The ICP calculates the rates of surgical site infections:*
  - ✓ *The numerator is obtained by totalling the number of surgical site infections following a particular operative procedure.*
  - ✓ *The denominator is obtained by totalling the number of patients having undergone that particular procedure over the quarterly surveillance period, obtained from the hospital's surgical database.*
  - ✓ *Rates of surgical site infection are presented per 100 procedures in the table below:*

Type of surgery	Number of surgical site infections following surgery (Q1)	Number of patients undergoing surgical procedure (Q1)	Rate of infection (No. infections per 100 procedures)
Knee replacement surgery	2	150	Calculation: $\frac{2}{150} \times 100 = 1.3$ per 100 procedures
Hip replacement surgery	4	125	3.2 per 100 procedures
Laminectomy	2	75	2.6 per 100 procedures
CABG	7	250	2.8 per 100 procedures
Colectomy	10	250	4.0 per 100 procedures
Abdominal hysterectomy	4	91	4.4 per 100 procedures

D. HOW OFTEN ARE SURVEILLANCE RATES CALCULATED?

For closer monitoring of changes to the risk of acquiring HAIs, many health care settings will calculate rates of HAIs on a monthly basis. HAI rates are commonly calculated monthly. Surveillance data may be summarized and presented quarterly to facility committees, patient/resident care staff and other stakeholders.

For example, calculating MRSA infection rates on a monthly basis will allow the Infection Control Team to track these microorganisms and respond to the changing risk of infection in a timely manner. Some special care areas, such as ICUs, may also calculate rates of device-associated infections on a monthly basis for faster response to clusters of infection among its highly susceptible patient group.

Box 13: Example Calculation of Incidence Density of Antibiotic-resistant Organisms (AROs)

- *For the numerator, the ICPs total the number of persons both colonized and infected with MRSA and/or VRE.*
- *As all patients are at risk for colonization or infection with MRSA and/or VRE, the denominator for this rate is the total number of patient days among those admitted to hospital during the surveillance period.*
- *Monthly rates of colonization and infection are calculated in addition to quarterly rates, in order to detect increases that will require immediate intervention. The ICPs obtain the number of days that all patients spent in hospital from the hospital's administrative database and totals this to obtain the denominator for both the monthly and quarterly surveillance rates:*

Patient ID	Admission date	Discharge date	MSRA cultures	VRE cultures	Number of days in hospital
0001	Jan 1, 2007	Jan 2, 2007	Negative	Negative	1
0002	Jan 1, 2007	Jan 8, 2007	Negative	Negative	7
0003	Jan 1, 2007	Feb 16, 2007	Positive	Positive	45
0004	Jan 1,, 2007	Jan 16, 2007	Negative	Negative	15
0005	Jan 2, 2007	Jan 7, 2007	Negative	Negative	4
.	.	.	.	.	.
.	.	.	.	.	.
4500	Mar 31, 2007	.	Positive	No	15
Total Jan			**35 positive**	**19 positive**	**45,000 patient days**
Total Feb			**40 positive**	**25 positive**	**48,500 patient days**
Total Mar			**37 positive**	**21 positive**	**46,500 patient days**
Total Jan-Mar			**112 positive**	**65 positive**	**140,000 patient days**

- *From these data, rates of MRSA and VRE are calculated by dividing the number of infections/colonizations by the total number of patient days and multiplying by 10,000:*

MRSA	No. of laboratory- confirmed cases of MRSA	Total no. of patient days in hospital	Rate of colonization/infection
January	35	45,000	$\frac{35}{45{,}000} \times 10{,}000$ = 7.8 per 10,000 patient days
February	40	48,500	8.3 per 10,000 patient days
March	37	46,500	8.0 per 10,000 patient days
Total for 1st quarter:	**112**	**140,000**	**8.0 per 10,000 patient days**

VRE	No. of laboratory-confirmed cases of VRE	Total no. of patient days in hospital	Rate of colonization/infection
January	19	45,000	4.2 per 10,000 patient days
February	25	48,500	5.2 per 10,000 patient days
March	21	46,500	4.5 per 10,000 patient days
Total for 1st quarter:	**65**	**140,000**	**4.6 per 10,000 patient days**

- *The rates expressed in the table above are per 10,000 patient days. The low frequency of MRSA and VRE colonization and infection relative to the total number of days that patients spent in a hospital/long-term care home makes the infection rate expressed per 10,000 patient days more appropriate. Hospitals and long-term care homes should present their rates using the same denominator as that of other health care settings or national benchmarks to which they wish to compare.*

Box 14: **Calculation of Incidence of HAI (long-term care example)**

Example #1: Urinary Catheter-associated UTIs

- *The ICP at Forest Manor collects data on the use of indwelling urinary catheters from the forms completed by ward nurses.*
- *The ICP inputs data from the forms into an electronic spreadsheet and totals the number of catheter-days in the resident population and the total number of UTIs in this group:*

Resident ID	Date of catheter insertion	Date of catheter removal	Date of UTI	# Catheter-days
0001	Jan 21	March 3rd	March 3	41
0002	.	.	.	.
0003	.	.	.	.
0004	Feb 1	.	No infection	59
0005	.	.	.	.
.	.	.	.	.
.	.	.	.	.
0100	March 7	March 31	March 31	24
Total for first quarter:			**7 infections**	**1,790 catheter-days**

- *There were 1,790 indwelling catheter-days at Forest Manor over the quarterly surveillance period and 7 symptomatic urinary tract infections among residents with indwelling catheters. The rate of catheter-associated UTIs is:*

$$\frac{\text{7 UTIs in residents with indwelling catheters}}{\text{1,790 catheter-days}} \times 1{,}000 = 3.9 \text{ UTIs per 1,000 catheter-days}$$

Example #2: Lower Respiratory Infections

- *The population at risk for lower respiratory tract infections includes all residents at Forest Manor.*
- *Sixty-one lower respiratory tract infections were identified over the quarterly surveillance period.*
- *As all residents at Forest Manor are at risk for respiratory tract infections, the denominator for this rate is the total number of resident days.*
- *Forest Manor's billing database indicates that there were 16,940 resident days over the quarterly surveillance period. The rate of HAI is:*

$$\frac{\text{61 lower respirator tract infections}}{\text{16,940 resident days}} \times 1{,}000 = 3.6 \text{ infections per 1,000 resident days}$$

Recommended Best Practice #11:

Electronic systems that store data and assist with the calculation of HAI rates should be used in health care settings.

E. ASSIGNMENT OF HAI TO SPECIFIC SURVEILLANCE PERIODS

Infections are typically associated with the date of onset of symptoms. However, in certain cases, infections identified in the current surveillance period may have resulted from an exposure that took place in the previous surveillance period. This is particularly true for SSIs related to joint surgery, where an infection can take up to one year to develop. Case definitions for health care-associated infections should take these factors into account.

F. HOW TO ORGANIZE DATA IN ELECTRONIC FORMAT FOR CALCULATION OF RATES

The examples in Boxes 11 to 14 show the calculation of HAI rates from data compiled in an electronic spreadsheet/database. Recommended practice is that all health care settings have a computerized system to track and monitor patient/resident surveillance data. This system should also allow for the analysis of infection data or, at a minimum, allow the data to be exported to a statistical analysis program.[85]

Where electronic systems are used to store and analyze data, HAI rates can be calculated with greater ease and efficiency and are less prone to error, provided that the ICP has received training in the use of such programs. Health care settings that do not use specific infection control computer programs should track infections using a spreadsheet or database program. Several simple statistical software packages are available and are compatible with most spreadsheet/database programs. ICPs requiring assistance in setting up an electronic system or selecting a simple statistical software package compatable with most hospital data spreadsheets may be able to contact their facility's information technology staff, local public health unit, Regional Infection Control Networks (RICN) or their peers for guidance.

G. HOW TO HANDLE MISSING DATA

Occasionally a hospital or long-term care home will encounter missing data in the calculation of their HAI rates. Missing data are common when doing post-discharge surveillance for SSIs, as many patients are lost to follow-up and their infection status will be unknown. There are several ways to deal with surveillance results when some of the data are not available:

- If it is unknown whether a patient/resident developed an infection then this person should be excluded from both the numerator and the denominator in rate calculations.
- As a general rule, if the number of patients at risk for an infection excluded from a rate exceeds 20 per cent because of missing data, then the validity of the rate may be jeopardized.[149]
- The rate should be reported with the caveat that "*over X per cent of patients at risk were excluded from the rate due to missing observations*".
- Hospitals and long-term care homes should keep track of the type of data that is most frequently missing and enhance efforts to ensure the completeness of the data.

6. Apply Risk Stratification Methodology

Patients/residents served by differing health care settings have differing risk factors related to the treatments and procedures that they undergo. These risk factors may be either extrinsic (e.g., environment-related) and/or intrinsic (patient-related) risk factors for HAI, including underlying disease condition and advanced age.Without adjustment for these factors, comparisons within the same health care setting or inter-facility comparisons may be invalid or misleading.[172]

For example, comparison of rates of infection between a community hospital and a tertiary care hospital may show a substantially higher rate of HAI in the tertiary care hospital. This difference may be due to several factors:

- higher degree of susceptibility to HAI in the more acutely ill population served by the tertiary care hospital
- the number of health care workers in direct contact with the patient
- the greater invasiveness of procedures undertaken in the tertiary care setting.

Hence, comparisons between these two hospitals will not be meaningful as the infection risks are very different.

A. RISK STRATIFICATION

Stratification is a process to control for differences in the underlying risk factors for infection. Risk stratification involves categorizing patients/residents with similar susceptibilities to infection and calculating the HAI rates based on these groupings. Risk stratification allows for meaningful comparison of rates among patients/residents with similar risks within a health care setting or between health care settings and at different points in time.[150-152]

Risk stratification in long-term care

Risk stratification of HAIs in long-term care is uncommon, but may provide useful information. For instance, it is recognized that long-term care residents with limited mobility who require assistance with daily living are at higher risk of lower respiratory tract infection. Resident mobility could be developed as an indicator of risk for health care-associated respiratory infection in the long-term care setting.

Risk stratification in acute care

Risk stratification methodology is generally applied to surgical site infections and, occasionally, to other types of infections (e.g., neonatal infection rates stratified by birth weight). Rates of HAI are often stratified by the major non-modifiable risk factors pertaining to that infection. [153, 172, 173]

Surgeries can be classified by wound class, i.e., the likelihood of contamination of the surgical site at the time of the operative procedure[154, 155]:

- Surgical procedures falling into the clean wound class category (class I) are non-emergency, involve access only to the sterile body sites and carry the lowest risk of surgical site infection.[143]
- Procedures falling into the contaminated wound class (class III) carry a high risk of infection often because they involve unusual contamination from a non-sterile site (e.g., large bowel resection contaminated with faecal material).

Wound class is often determined by the nature and urgency of the procedure and is unrelated to IPAC practices. Therefore, stratification of infection rates by wound class allows for the comparison of SSI among procedures that carry similar risks.[156]

Refer to Appendix H for a description of wound classes.

Recommended Best Practice #12:

Rates of procedure-specific surgical site infections should be stratified by wound class.

B. USING RISK INDICES IN STRATIFICATION

Risk indices are used to combine several risk factors for a particular infection, rather than calculating a separate rate for each of these factors. In selecting a risk index, the ICP should use categories of risk that have been validated for predicting the risk of infection. Limited progress has been made in developing practical risk indices that have been shown to correlate well with the risk of HAI. One example, the Acute Physiologic and Chronic Health Evaluation (APACHE II), is a scoring system used to establish severity of illness among ICU patients, which is thought to correlate with the risk of acquiring a HAI. However, the APACHE system has had limited utility in predicting risk of HAI because the patients with the highest scores generally do not survive long enough to acquire a HAI.[108]

A risk index is only useful if the risk index is correlated with the actual risk of infection in a health care setting.[151] An example of a risk index that has been used by NHSN in the past that related to both the patient and the characteristics of the procedure included:

a) length of the operative procedure beyond the 75th percentile cut-off for that procedure (1 point)
b) wound class score ≥ 3 (1 point)
c) the American Society for Anesthesiologists (ASA) score of 3, 4 or 5, which summarizes the extent of underlying illness and functional limitations of a patient (1 point)

With this risk index, all patients received a score from 0 to 3 points. One of the advantages of this risk index is that it facilitates comparison of HAI rates with other hospitals, adjusting for risk. The index components (i.e., wound class, ASA score, length of operative procedure) are also easily obtained from a hospital's surgical database information. There are, however, limitations to this method and risk index does not accurately predict risk for some surgical procedures, such as cardiovascular surgery and spinal surgery.[151] Specific patient risks differ for different types of surgery.

Figure 7 illustrates a sample chart abstraction tool for all patients undergoing cardiovascular surgeries that can be used to gather key data on SSIs and other risk factors for use with this risk index. A hospital may find this tool useful when the information cannot be obtained directly from a health care facility's surgical database.

Pearl of Wisdom: *The information required for risk stratification (e.g., wound class, length of procedure) needs to be collected from both the patients developing infections and the patient population at risk.*

Patient Information

Name:_____

HFN:_____

DOB:_____

Date of OR:_____

Patient ASA score: ☐ **0** ☐ **1** ☐ **2** ☐ **3** ☐ **4**

OR Information

Procedure: _____

☐ CABG x _____

SVG L R

Radial L R

LIMA RIMA

☐ Valve Replacement/Repair

☐ Off Pump Procedure

☐ Thoracotomy

☐ Endoscopic Vein Removal

☐ Aorta Repair

Wound class: ☐ **1** ☐ **2** ☐ **3** ☐ **4**

Length of procedure: _____

Other intraoperative findings: _____

_____

Antibiotic Prophylaxis:

Preop – drug and dose: _____

Timing: _____

Treatment:

Intraop – drug and dose: _____

Timing: _____

Information about Infection

Patient developed SSI? ☐ **YES** ☐ **NO**

IF YES:

Date of SSI identification:_____

Site:_____

Culture Results:

Organism: _____

Date: _____

Site: _____

Radiographic Evidence:

Date: _____

Results: _____

Signs and Symptoms of Infection:

Physician diagnosis of infection:

Treatment: _____

Date: _____

Type: _____

Notified By:

PDS Lab Floor Readmit ID

Other: _____

[Adapted from: Sunnybrook Health Sciences Centre, Toronto, Ontario]

Figure 7: Sample cardiovascular surgical site infection chart abstraction tool

Box 15 provides an example of calculating risk stratification based on wound class in a fictional hospital.

Box 15: Application of Risk Stratification Methodology (acute care example)

- *The Infection Control Team at City General Hospital stratifies its rates of surgical site infections for cholecystectomy and colectomy by wound class.*
- *The team obtains information on wound class for each patient undergoing cholecystectomy and colectomy over the quarterly surveillance period from the hospital's surgical database:*

Patient ID	SSI	Wound class
Colectomy		
0001	No	II
0002	No	II
0003	Yes	III
.	.	.
.	.	.
0250	No	III
Total	**10 infected/ 250 total**	
Cholecystectomy		
0001	No	I
0002	Yes	I
0003	No	II
.		
0300	Yes	III
Total	**11 infected/300 total**	

- *The infection control team totals the number of patients in each wound class and calculates the following rates:*

Surgical Site Infections	Surgical site infections following surgery	Total number of patients undergoing surgical procedure over quarter	Rate of infection (No. infections per 100 procedures)
Colectomy	10	250	= 10/250 x 100 = 4.0 per 100 procedures
Wound class I-II	4	190	2.1 per 100 procedures
Wound class ≥ 3	6	60	10 per 100 procedures
Cholecystecomy	11	300	3.7 per 100 procedures
Wound class I-II	5	250	2.0 per 100 procedures
Wound class ≥ 3	6	50	12.0 per 100 procedures

While the NHSN risk index is the most widely-used risk index for health care-associated infections, several investigators have shown that it was unable to accurately predict the risk of infection across a wide range of surgical procedures.[154, 155, 157, 158] Some health care settings may find the NHSN SSI risk index useful because it allows them to compare their rates of infection with other hospitals also using this index. However, its inability to adjust for the true risk of SSI should be recognized.

In the Know

NHSN has introduced Standardized Infection Ratios (SIR) as a comparator for HAI over time.[151] While the NHSN system is in transition, hospitals should continue to compare their HAI rates with the system that they are currently using, so they can continue to benchmark their rates against their own historical rates and those of peer hospitals that use the same system.

If changes are made to the way data is stratified in a facility, the date of the change must be noted and future data can only be compared to data generated after the change.

The standardized infection ratio (SIR)[151] is a summary measure used in the U.S. to track HAIs at a national, state, or facility level over time. The SIR adjusts for the fact that each health care facility treats different types of patients. The method of calculating an SIR is similar to the method used to calculate the Standardized Mortality Ratio (SMR), a statistic widely used in public health to analyze mortality data. This information is not currently available in Canada. For more information about standardized infection ratios, visit the NHSN website at: www.cdc.gov/hai/national-annual-sir/index.html.

7. Interpret Infection Rates

Infection Control Professionals must be able to interpret HAI rates so that they can identify areas where improvements to IPAC practices are needed to lower the rate of infection, or to evaluate where preventive interventions have been effective in reducing the risk of infection. Interpreting the meaning of a rate of infection requires a close working knowledge of how one's surveillance system operates and of the changing risks of infection in one's facility. The recommended steps in interpretation of surveillance rates are summarized in Figure 8.

A hospital or long-term care home should use the following questions to guide the interpretation of a surveillance rate:

A. ARE THE RATES ACCURATE?

As a first step in interpretation of an infection rate, the ICP should ask: *have the rates been accurately calculated*?

- It is recommended that all HAI rate calculations be pre-programmed into your computerized system or spreadsheet/database. Calculation of surveillance rates through a computerized system will eliminate some of the potential for the miscalculation of rates and save valuable ICP time.
- It is also recommended that another member of the Infection Control Team review, and if necessary re-calculate, the rates using your infection data. If discrepancies in the rates are found, then identification of the area of miscalculation can serve to reinforce methods and provide additional practice in calculation of rates.

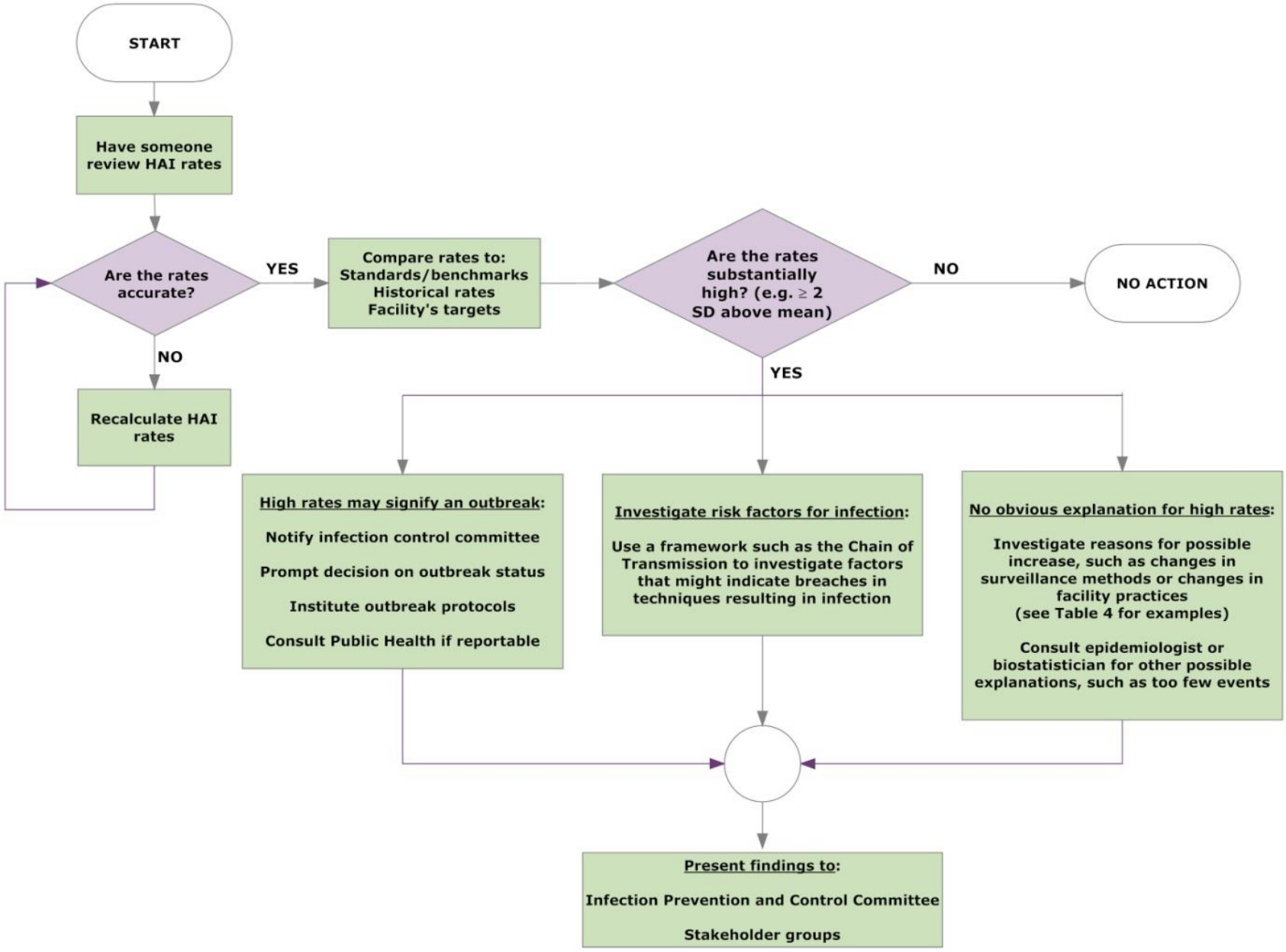


Figure 8: Recommended steps in interpretation of surveillance rates

Recommended Best Practice #13:

A colleague should review HAI rates and check their accuracy prior to any interpretation of the rate.

B. ARE THERE ANY MAJOR DEVIATIONS FROM PREVIOUS DATA? DO THE RATES MAKE SENSE?

At this point, the ICP will notice if a rate deviates substantially from previous surveillance periods. ICPs may substantiate this statistically through the use of a standard deviation.

i. Using standard deviation to assess data

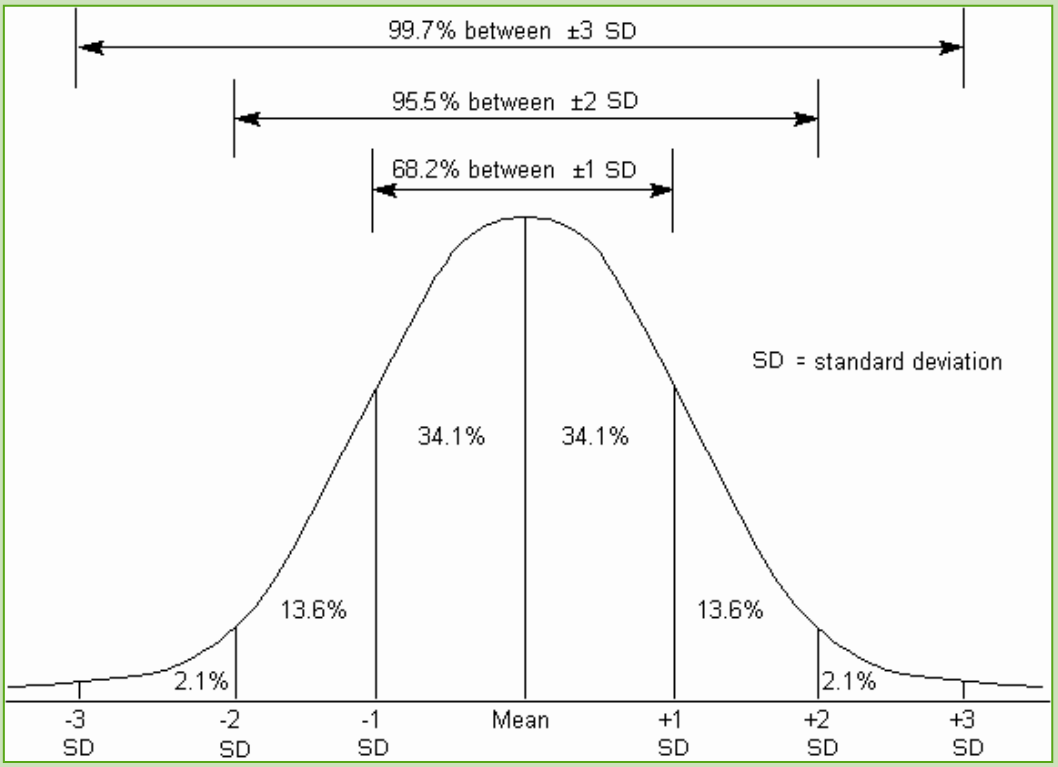
The standard deviation (SD) of a rate of infection indicates the average spread or dispersion around the mean rate, i.e., data values will lie somewhere above or below the average that has been calculated from all of the values. A rate that is farther than +2 SDs from the mean rate of infection represents an unusual occurrence. The Infection Control Team could seek the assistance of a biostatistician/epidemiologist in calculating the mean rate and standard deviation to assist them in interpreting whether a difference is substantial, especially when numbers are small, data are not normally distributed or to evaluate changes in processes.

Standard deviation should never be used alone to determine outbreaks. The calculation of the SD should be done using non-outbreak periods of time when HAI rates are within normal limits. Outbreak data should never be used to calculate the standard deviation.

See Box 16 for a graphical illustration of how the standard deviation may be used to guide action when HAI rates appear to be elevated.

Box 16: Use of Standard Deviation to Guide Decision-making Related to Increases in HAI Rates

- *Using standard deviation (SD) calculated from HAI rates, it can be seen from the graph below that 95.5% of HAI rates will fall within ± 2 SD of the mean rate. This can be used to determine, on a month-to-month or quarterly basis, whether a particular infection rate is acceptable or is abnormally high.*



- *For example, after generating monthly rates for MRSA colonization in Forest Manor, at the end of a year the ICP calculates a mean rate of 2 cases per 1,000 resident days.*
- *Using the rates from the previous 12 months to calculate the standard deviation results in a standard deviation of 1.*
- *This means that, in any given month, 68.2% of the time the MRSA colonization rate will fall between 1 and 3 cases per 1,000 resident days (mean ± 1 SD) and 95.5% of the time the MRSA colonization rate will fall between 0 and 4 cases per 1,000 resident days (mean ± 2 SD).*
- *If ± 2 SD is considered acceptable, then only months where the rate was above 4 cases per 1,000 resident days would require investigation.*

Process control charts are used in some facilities to determine when infection rates are too high and require action. Process control charts were initially developed in industry in 1931 to provide information about a process behaviour[159] and they have been successfully used for quality control initiatives in hospitals and in syndromic surveillance.[160, 161] One use for process control charts in IPAC would be monitoring the process of care, such as hand hygiene and immunization rates.

ii. Using critical thinking to assess data

If no errors are detected in the calculation of a rate and the rate is substantially higher or lower than expected, then the ICP should ask: *do these rates make sense*?

The ICPs' day-to-day activities in case finding provide them with a general idea of the range of frequencies of various types of infections that can be expected in their facility. The ICP can apply this working knowledge to assess whether a particular rate of infection seems reasonable, based on what they have observed in their facility over the surveillance period.

Unusually high HAI rates that signify a cluster or outbreak would normally come to the attention of the ICP before HAI rates are calculated. If an unusually high rate of infection indicates an outbreak, then the ICP should bring this to the immediate attention of the Infection Control Team and implement their outbreak management protocols if required.

Substantial deviations in HAI rate from previous surveillance periods that are not explained by an outbreak situation should be investigated by the ICP and Infection Control Team. These differences could indicate:

- changes in hospital practices
- changes in surveillance methodology
- changes to case definitions.

Box 17: Example of How Changes to Hospital Practices Appear to Affect the Infection Rate[74]

The following demonstrates how changes in facility practices in one community hospital impacted case finding for surveillance and resulted in an apparent decrease in the rates of MRSA infection over time:

The Infection Control Team at this hospital was elated when the proportion of S. aureus isolates that were resistant to methicillin decreased from 34 to 0 per cent in one surveillance month. Upon further investigation, it was found that two changes in the hospital, unrelated to the risk of MRSA, were responsible for this change. First, surgeons had begun to treat potentially infected wounds based solely on signs and symptoms. Second, the hospital laboratory began screening wound specimens and selected a limited set, meeting specific criteria, for culture. Together these changes reduced the total number of S. aureus isolates that were available for testing for methicillin resistance, including those that were positive. The observed reduction in MRSA infections were attributed to these facility changes, impacting the sensitivity of case finding, rather than to any changes in infection prevention and control practice.

Decker/Pottinger , A Practical Handbook for Hospital Epidemiologists 1998

Additional examples of changes to hospital practices and the apparent change to the rates of HAI that can result from these changes are provided in Table 4.

Recommended Best Practice #14:

The possibility that differences in rates of infection in your facility from previous surveillance periods may be the result of changes in institutional practices or surveillance practices should be explored.

Table 4: Examples of Practices that Affect Observed Infection Rates

Change in Practice	Apparent Effect on Infection Rate
Increasing proportion of treatment taking place in outpatient setting rather than in hospital	Decrease in overall infection rate, because surveillance is rarely performed in the outpatient setting OR Increase in infection rate if low-risk procedures are performed in the outpatient setting and those taking place in hospital are among high-risk surgical patients
Length of stay in hospital following treatment is decreased	Decrease in overall rate of infection because fewer infections are detected post-discharge OR Increase in infection rate as patients staying in hospital are more severely ill and at a greater risk of infection
Patients residing in lodging house or boarding unit of hospital are not counted as admitted patients; thus, these patients are not included in the denominator	Increased infection rate if surveillance is conducted on these units, especially if outbreaks of infections on these units (e.g., *C. difficile*, gastroenteritis) are detected
Automated IT services office associates surgical procedure to admitting physician, regardless of physician's specialty, rather than to the surgeon performing the procedure	Inaccurate surgeon-specific infection rates, because some surgical site infections will be assigned to the wrong surgeon
Physicians treat patients based on signs and symptoms of infection, without obtaining cultures	Decreased rate of infection if case finding relies solely on microbiology reports
Microbiology laboratory changes screening criteria for processing specimens	Decreased rate of infection if case finding methods rely on laboratory reports
Definitions inconsistently used or inconsistently applied	Inaccurate infection rates

iii. Temporal variations impacting on data

Rates of infection may vary from previous surveillance periods due to changes related to time:

- seasonal variations - for example, respiratory infections have a low frequency in the summer months but may increase over the winter months
- weekly variations - for example, onset of infection over the weekend may not be recognized or confirmed until Monday when patient/resident care and laboratory staffing levels increase, which may result in a higher number of infections being recorded on that day.

These contextual factors should also be considered in interpretation of a surveillance rate. If a health care setting is doing seasonal surveillance (e.g., influenza surveillance), the same time period must be used each year when doing trend comparisons.

C. RATE COMPARISON TO BENCHMARKS

It is recommended that health care settings compare their HAI rates against benchmarks, both internal and external. There are three common rate comparisons that may be used: [169, 74]

1. Recognized standards or benchmarks

A hospital or long-term care home can evaluate their rates of infection relative to an established benchmark (e.g., NHSN, CNISP, ECDC). ICPs may use these benchmarks if their surveillance data have been collected in the same way as that of the benchmarked rate.

For some infections there are recognized rate standards. For example, the mean rate of infection for clean laminectomies is 0.78 per cent.[162] For other infections where there are no well-established benchmarks, a group of similar health care settings may choose to benchmark against each other.

2. Rates from previous surveillance periods

Depending on the infection of interest, health care settings should choose to compare their HAI rates to those calculated in previous surveillance periods (e.g., previous month, previous quarter, previous year) and excluding months with outbreaks, to detect changes in the risk of infection or deviations from a baseline rate, or to evaluate the effectiveness of interventions that have been implemented.

3. Benchmarks set by one's own facility

In a well-established, ongoing surveillance system, the IPAC team will have a good idea of its baseline HAI rates, which may be lower than external benchmarks. In such cases, the hospital or long-term-care home may set their own goals for HAI rates based on what can be achieved in their facility and compare rates of infection to their own internal benchmarks.

4. Benchmark is not available

If an appropriate benchmark is not available for a specific indication and one is required, (e.g., for costing purposes), a health care setting may determine its own benchmark based on a review of the published literature related to the specified indication.

In comparing HAI rates to those of other hospitals or long-term care homes, an ICP should review the surveillance methods used by these facilities. This review can assist in identifying whether differences in the rates of infection can be attributed to surveillance methods, such as different approaches to case finding, or to the use of different case definitions. Upon review of the surveillance methods of several other facilities, a health care setting should be able to identify those that use the same case definitions and similar approaches to case finding. This set of peer facilities can provide an ongoing comparison group of surveillance rates.

If the ICP suspects that there is a meaningful difference in their rate of infection relative to other facilities or to previous surveillance periods, then consultation with an epidemiologist or biostatistician can assist in determining whether any differences in the risk of infection are statistically significant. Some facilities may have this expertise available, while others may have to seek out someone with this training. The local public health unit is a good source of expertise. Another source of assistance in interpretation of surveillance rates is the Department of Epidemiology/Biostatistics of a nearby university.

Pearl of Wisdom: *Comparisons over time or across health care settings are only appropriate if the same case finding methods have similar sensitivities and specificities, the same case definitions are applied to establish infection and the same methods are used to calculate rates of infection and to adjust for risk factors.*

Recommended Best Practice #15:

A set of peer institutions should be identified that use the same case definitions and similar case finding methods, to serve as a comparison group. When comparing HAI rates to those of other hospitals or long-term care homes, an ICP should consider the surveillance methods used by these facilities.

iv. Effects of sample size

While HAI rates may be accurately and consistently calculated over time, they may not be very meaningful if the number of events (i.e., numerator) is small.[163] For example, in the sample dataset shown in Box 12, there were only two reported SSIs following laminectomy over the course of a year. An increase in the number of laminectomy-associated SSIs (e.g, as few as two or three additional cases) would result in a 50 per cent increase in the SSI rate (assuming the denominator, or number of procedures, remained constant).

ICPs should consider the number of events on which a rate is based when interpreting surveillance rates. A low number of events results in instability in rates of HAI. An epidemiologist/biostatistician can assist in confirming whether there are too few infection events for clinically meaningful differences to be detected.

D. INVESTIGATION OF INCREASED HAI RATES

If the Infection Control Team determines that an increased HAI rate reflects a difference in the true rate of infection, then investigation of the cause of the increased rate is required. The '*Chain of Transmission'* model provides a useful framework to guide this investigation.

This model, illustrated in Figure 9, summarizes all components necessary to the process of infection, using MRSA as an example:

- MRSA is present in the community and hospital
- a patient with frequent hospitalizations who is colonized with MRSA may act as a reservoir in the hospital setting
- the portal of exit is the colonized patient's skin, which sheds MRSA into the environment
- the mode of transmission is from person-to-person
- the hands of a health care provider may serve as the vector for transmission, transferring MRSA bacteria from the colonized patient to the surgical wound of the patient's roommate
- the portal of entry in the roommate is the clean surgical site
- whether or not this exposure to MRSA results in a surgical site infection depends on the individual's susceptibility to infection.

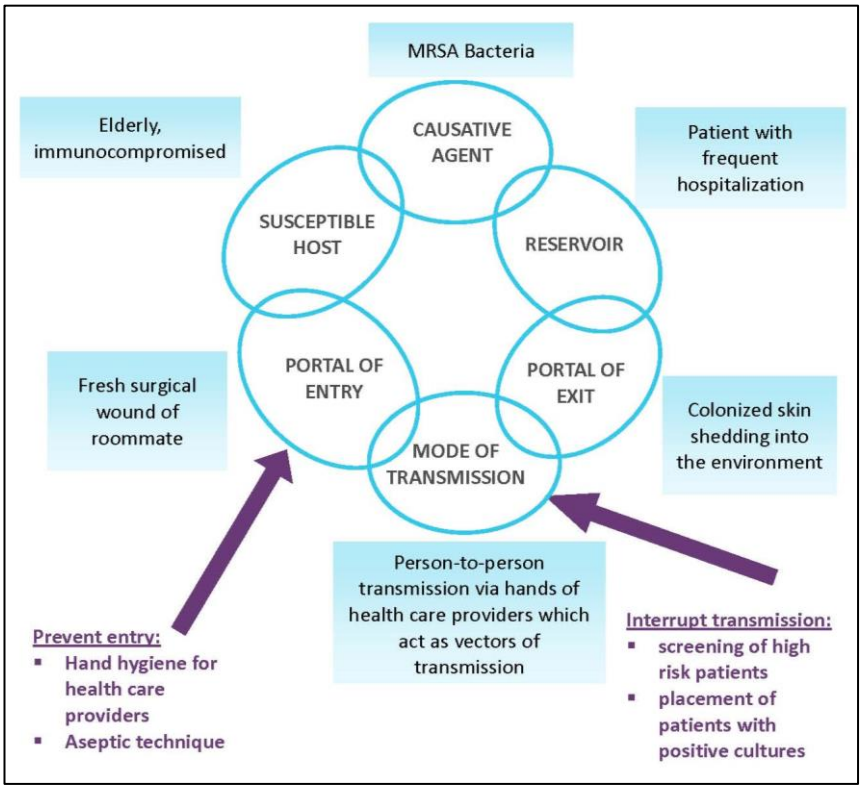


Figure 9: Chain of Transmission example: MRSA

Increases in HAI rates are not necessarily a reflection of a failure in patient/resident care or of facility practice. Differences in the rate of infection arise from many factors, including [172]:

- factors relating to the infectious agent, such as increased frequency of the microorganism in the hospital or community setting
- factors relating to the host, including an increasingly acutely ill and susceptible patient population in health care settings.

The *Chain of Transmission* model may be useful in identifying areas where the infection process can be interrupted through changes to IPAC practices. The model also useful when explaining changes in the epidemiology of HAIs.

Using the recommended steps in interpreting surveillance rates (Figure 8), reductions in the rate of MRSA infections may be achieved through enhanced IPAC practices, such as screening patients on admission and the use of Additional Precautions for those colonized with MRSA (to interrupt transmission) or improved hand hygiene in patient care staff.

Recommended Best Practice #16:

If the Infection Control Team finds that an elevated HAI rate represents an increased risk of infection, they should use a conceptual framework (such as the Chain of Transmission model) to suggest explanations for these rates and areas where improvements to infection control practices could reduce the rates.

E. DISCUSS INTERPRETATION WITH THE INFECTION CONTROL TEAM

Once the ICP has confidence in his/her interpretation of the HAI rate, it is important to share this with others on the Infection Control Team. Where a higher rate of infection is thought to reflect a greater risk of infection, this interpretation should form the basis for development of improved IPAC practices. After an IPAC program has been developed and implemented with patient/resident care staff, the eventual re-calculation of rates as part of a formal evaluation exercise would be used to assess the effectiveness this program, as demonstrated in the continuous feedback loop in Figure 1.

If the ICP is of the opinion that differences in rates of infection are due to small sample size or to changes in surveillance methods, then he/she should report this interpretation to the appropriate medical team. For example:

- An ICP might report a higher rate of SSIs over a particular surveillance period, while noting that the difference in rate was only due to one additional infection event over that period and that this rate of infection is not likely to be reflective of any changes in the risk for that particular infection.
- An ICP in a long-term care home might report a higher rate of urinary catheter-associated UTIs relative to other facilities in the region, with an explanation that their facility uses a case definition for UTIs that includes only positive culture results, whereas the other facilities use both clinical criteria and laboratory results to establish infections.

8. Communicate and Use Surveillance Information to Improve Practice

If surveillance data are not used to effect changes to IPAC practices, then the surveillance system is not working. Communication of surveillance data is both verbal and visual, and their use as an input to IPAC practice constitutes the end goal of an effective surveillance system.[84] A surveillance system that simply collects and houses data without communicating it to stakeholders stops short of attaining the main goal, that of improved IPAC practice and decreased rates of HAIs.

A. COMMUNICATION AT THE HEALTH CARE SETTING LEVEL

Communication of HAI rates takes place first at the health care facility level, often to a hospital or long-term care home's IPAC committee. This type of communication provides a global view of the risk of HAIs in the health care setting over a specified period of time. This communication, often in the form of a quarterly report, should outline any changes to the risk of infection across all patient/resident care areas that are covered by the surveillance system.

To assist clinicians and health care administrators to understand the interpretation of HAI rates, it is important to describe where this rate is situated relative to previous surveillance intervals or in relation to like facilities. For example, reporting a rate of 5.6 CLABSIs per 1,000 patient days may have little meaning to a hospital committee without knowledge as to what this rate signifies. Comparing this rate to a mean rate of infection available from a group of comparator facilities or an established benchmark rate and presenting this graphically with the facility's data are useful (refer to bar graph in Appendix I).

B. COMMUNICATION TARGETED TO A SPECIFIC AREA OF PATIENT/RESIDENT CARE

Communication of HAI rates should also be targeted to specific patient care areas or specialty services that have participated in the data collection, such as ICUs or surgical units in hospitals, or complex continuing care units in long- term care homes. These reports offer a more detailed analysis of the specific types of infections affecting patients/residents served by these particular care areas.

Information is generally presented as a written report. The targeted report may be distributed at a regular program committee meeting or could be used in a workshop, for example, which might comprise managers, health care providers and the ICP or Infection Control Team. The information

provided in this report may serve as a basis for discussion between the ICPs and the program's staff about emerging concerns in patient safety, reasons for changes in their rates of infection, or the effectiveness of specific IPAC practices and interventions.[46, 61, 164]

The information provided in surveillance reports can also be used to direct resource allocation in IPAC. This information should be directed to those able to effect change in the health care setting's practices. The dissemination of surveillance information should take place on a systematic, ongoing basis so that health care providers and administrators can use it in the evaluation and planning patient care practices.

All information provided in surveillance reports must be clear, easy to follow and provide only the information required. Information should be presented using a standardized format, as managers and/or health care providers often have little time available for an in-depth review of the data. Whenever possible, the Infection Control Team should employ visual aids, such as bar or pie charts, graphs and tables, in order to display surveillance data. Important trends, such as an increasing HAI rate, may be quickly identified when portrayed visually.

Refer to Appendix I for information regarding tools for the visual display of surveillance data.

Recommended Best Practice #17:

Communication of surveillance data should take place on an ongoing, systematic basis and be targeted to those with the ability to change infection control practice. All surveillance reports should be clear and easy to follow, including the use of visual aids including pie charts, bar charts and graphs.

C. COMMUNICATION OF SPECIAL ALERTS AND OUTBREAKS

Timely communication of alerts to health care providers following identification of an emerging risk of infection is important. For example, if the Infection Control Team detects a sharp increase in the rate of infections caused by MRSA in a particular patient/resident care area of their facility, they may issue a facility-wide alert documenting the increase. The alert may also serve as an opportunity to remind patient/resident care staff of IPAC practices, such as hand hygiene and routine MRSA screening practices for patients/residents admitted to that ward. Any additional IPAC precautions instituted in response to this increase in HAI rate may also be outlined in this alert.

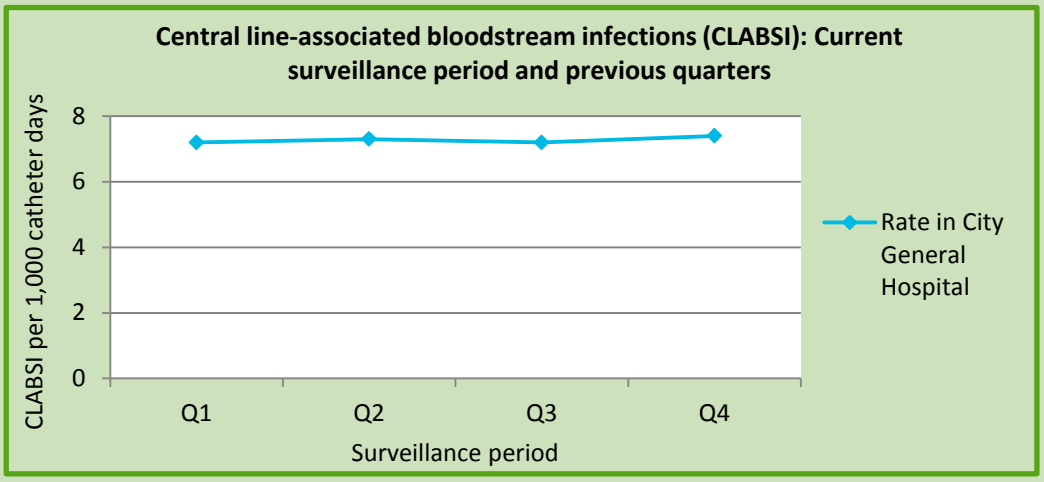
If a reportable disease is identified, the local public health unit shall be notified.[165]

As with surveillance reports, alerts should present only key information with the use of graphs or charts whenever possible to communicate the main messages quickly and effectively.

Examples of how an Infection Control Team can undertake the dissemination of information generated through a surveillance system are provided in Boxes 18 and 19.

Box 18: Communication and Use of Surveillance Information (acute care example)

- *At City General Hospital, the Infection Control Team collaborates closely with the ICU to investigate sources of HAIs.*
- *The Infection Control Team forms a working group with the ICU manager and medical director to address the risk of HAI on an ongoing basis.*
- *This working group holds a quarterly workshop with the patient care staff to evaluate and review changes to patient care practices aimed at reducing the risk of infection.*
- *CVC-associated bloodstream infections (CLABSI) are a major concern for the ICU working group. In preparation for this workshop, the Infection Control Team puts together a report documenting the risk of CLABSI among patients treated in the ICU over the past year.*
- *The graph below shows the BSI rate per 1,000 CVC-days:*



- *The ICPs from City General Hospital dialogue with other member hospitals of the Regional Infection Control Network and Infection Prevention and Control Canada.*
- *They find that City General Hospital's rates of CLABSI are 3 per cent higher than other similar hospitals serving similar patient populations; rates of these infections in other hospitals average 5 per 1,000 line days.*
- *The ICU working group is in agreement that improvements to patient care practices have the potential to decrease the risk of CLABSI.*
- *They find that City General Hospital uses similar approaches in surveillance and has a similar ICU case mix to other hospitals, and that differences in these factors are not likely to explain the difference in rates.*
- *Together, the ICP and ICU undertake steps to increase compliance with guidelines for the insertion and change of CVCs. The ICPs embark on an education initiative among patient care staff to raise awareness of the guidelines for CVC insertion (e.g., that it take place under maximum barrier precautions) and for frequency of CVC changes. The ICU manager and medical director work to ensure that all necessary supplies are available for maximum barrier precautions for insertion and implement a reminder system for central line change.*

The following key features help to ensure that surveillance graphs are easy to interpret:

- The graph has a clear title with date and a subtitle that summarizes the data being presented.
- Both axes are labelled, with time generally presented on the 'x' (horizontal) axis and the rate of infection usually presented on the 'y' (vertical) axis.
- The units of the scale on the 'y' axis should be constant, wherever possible. If showing a percentage, the values should be 0 to 100.

- The denominator is clearly indicated (e.g., per 1,000 central line days).
- The timeframe of interest is clearly indicated (current and past quarterly surveillance periods).
- There is a legend to accompany the data shown in the graph.

Unlabelled or improperly labelled axes and graphs without legends are common pitfalls impeding communication made by those presenting data that are easily rectified.

Box 19: Communication and Use of Surveillance Information (long-term care example)

Urinary Tract Infections

The ICP at Forest Manor follows potential cases of UTI as reported from the ward staff and finds an increase in the number of symptomatic UTIs associated with indwelling urinary catheters.

Following collection of data on the population at risk, the ICP finds that the rate of UTIs per 1,000 catheter days has not increased from previous periods. The number of resident catheter days has, however, increased from previous periods.

The ICP reasons that the increased number of UTIs is due to an increase in the exposure to indwelling catheters.

The ICP shares this information with nursing and administrative staff at the monthly staff meeting and initiates discussions on potential reasons for the increase in indwelling urinary catheter use and on ways that the use of these devices can possibly be decreased.

Acute Respiratory Infections

The ICP at Forest Manor also compiles data on the rates of lower respiratory tract infections in residents over the past five previous influenza seasons.

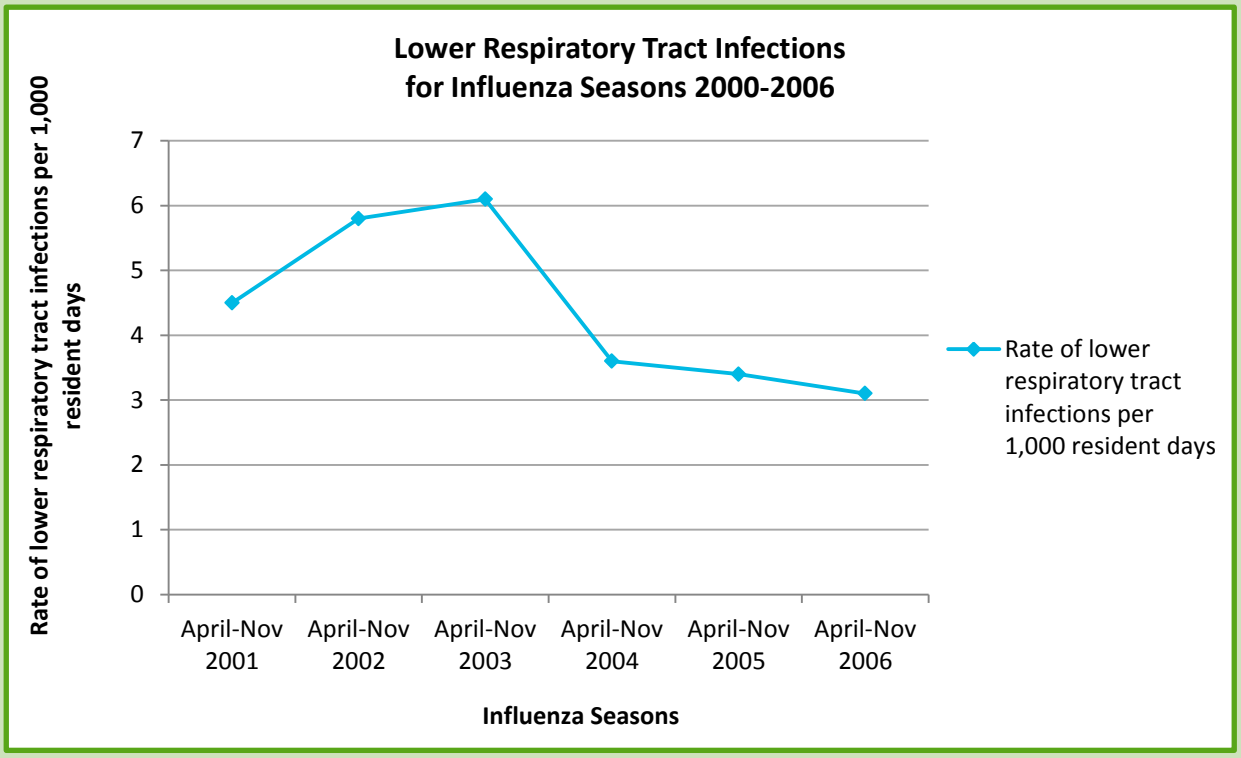
The ICP presents this data alongside the percentage of patient care staff receiving annual influenza vaccination, as documented in employee records, in the graphs below.

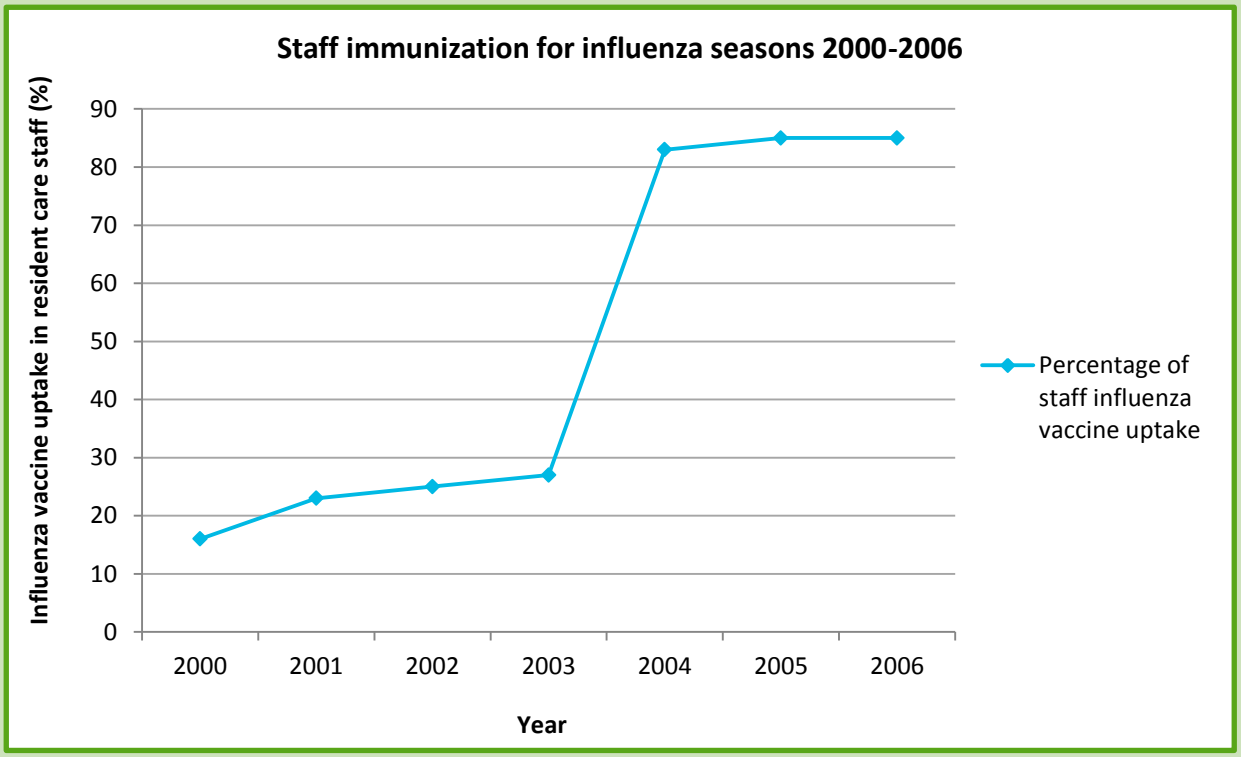
The graphs demonstrate a substantial decline in the rates of respiratory tract infection over the last two influenza seasons at Forest Manor, coinciding with the highest rates of vaccine uptake among health care providers.

At Forest Manor, the percentage of immunized health care providers increased modestly from 2001 to 2003 following an active education campaign to increase compliance with vaccine recommendations.

It was only in 2005, when vaccination coverage was at its highest, that the most substantial impact on lowering the rates of lower respiratory tract infections was achieved.

These data clearly demonstrated the impact that health care provider immunization had on respiratory tract infections in residents, and they were used to form the institutional policies necessary to achieve vaccine coverage in staff.


Lower Respiratory Tract Infections
for Influenza Seasons 2000-2006
Rate of lower respiratory tract infections per 1,000 resident days
7
6
5
4
3
2
1
0
April-Nov 2001
April-Nov 2002
April-Nov 2003
April-Nov 2004
April-Nov 2005
April-Nov 2006
Influenza Seasons
Rate of lower respiratory tract infections per 1,000 resident days


Staff immunization for influenza seasons 2000-2006
Influenza vaccine uptake in resident care staff (%)
90
80
70
60
50
40
30
20
10
0
2000
2001
2002
2003
2004
2005
2006
Year
Percentage of staff influenza vaccine uptake

9. Evaluate the Surveillance System

A final recommended practice is evaluation of the surveillance system, which entails a review of:

- how efficiently and effectively the surveillance system works (process evaluation)[166]
- how the information produced by a surveillance system is used to reduce the risk of health care-associated infection (outcome evaluation).[167]

A. PROCESS EVALUATION

A surveillance system should have built-in procedures for the evaluation of how the system is working on a day-to-day basis.[103] Periodic review of surveillance methods should be incorporated as part of regular Infection Control Committee meetings. These review sessions will provide an opportunity for the Infection Control Team to review case definitions, case finding methods (including number of potential cases missed) and other surveillance procedures to ensure consistency in application. The participation of internal/external peers, such as Infection Control Professionals from other health care settings, at these sessions can provide a helpful perspective and new ideas and suggestions as to how a facility's surveillance system may be improved.[96, 104]

An example of a peer review session to evaluate surveillance definitions may be found in Box 20.

Box 20: Surveillance Process Evaluation (acute care example)

- *The Infection Control Team at City General Hospital invites ICPs from nearby member hospitals within the Regional Infection Control Networks and an epidemiologist from the local public health unit to join them in an exercise that will assess the consistency of application of case definitions for infection.*
- *A series of charts from patients with suspected or confirmed health care-associated infections are selected at random and all participants at the review apply case definitions, deciding whether a particular case meets the definition for infection based on all available chart information.*
- *The group discusses and challenges each others' application of case definitions and comes to consensus on certain issues.*
- *This exercise assists in assuring consistency in application of case definitions both within City General Hospital and in other institutions in the region.*

B. OUTCOME EVALUATION

The Infection Control Team may use the following questions to evaluate how the surveillance system is impacting IPAC and how the information produced from surveillance is used to reduce HAIs in their health care setting[85]:

- Did the surveillance system detect clusters or outbreaks?
- Which patient/resident care practices were changed based on surveillance data?
- Were data used to assess the efficacy of interventions?
- Were data used to make procedural changes to decrease the endemic rate of infection?
- Is surveillance of this infection still of value (if the number of cases or rate of infection is exceptionally low, then surveillance for the infection may not be warranted)?

Where surveillance data are not used as effectively as they could be to effect changes to practice, the Infection Control Team should examine the underlying reasons for this and if necessary make changes to its surveillance system.

C. ONGOING SURVEILLANCE SYSTEM IMPROVEMENT

It should be expected that a surveillance system will undergo continual modification or re-alignment to ensure that it is working towards improved infection prevention and control, as demonstrated in Figure 1 by the continuous feedback loop of the surveillance system components. Modifications to a surveillance system might include:

- re-assessment of the infections monitored
- changes to the approach to case finding
- ways in which information generated by the system is communicated to other health care providers and decision-makers.

Recommended Best Practice #18:

The surveillance process implemented in a facility (e.g., application of case definitions, case finding and communication methods) should be regularly reviewed and modifications made as needed.

At least annually, the outcomes of surveillance systems (i.e., reductions to the risk of infection) should be reviewed and system objectives re-aligned as required.

III. Summary of Best Practices

This summary table is intended to assist with self-assessment internal to the health care setting for quality improvement purposes. See complete text for rationale.

	Recommendation	Compliant	Partial Compliance	Non-compliant	Action Plan	Accountability
BEST PRACTICES FOR SURVEILLANCE OF HEALTH CARE-ASSOCIATED INFECTIONS						
1.	As a first step in the planning of a surveillance system, a health care setting should assess: • the types of patients/residents that it serves; • the key medical interventions and procedures that they undergo; • the types of infections for which they are most at risk. This assessment is done to establish priorities for the surveillance system. [AIII]					
2.	Syndromic surveillance of respiratory infections and gastroenteritis should be undertaken in all hospitals and long- term care homes. Where hospitals and long-term care homes select outcomes for surveillance in addition to the infections listed above, the following should be considered: • the frequency of the infection; • the impacts of the infection (including per cent case fatality and excess costs associated with the infection); and • the preventability of the infection. In both hospitals and long-term care homes, the outcomes selected for surveillance should be re-evaluated at least annually. [AII]					
3.	Hospitals should use standardized, validated case definitions for surveillance (Appendix C) and apply the definitions consistently. [AIII]					
4.	Long-term care homes should use standardized, validated definitions for health care-associated infections in long-term care as provided in Appendix D. [AIII]					

Recommendation		Compliant	Partial Compliance	Non-compliant	Action Plan	Accountability
5.	Steps should be taken in hospitals and long-term care homes to ensure that case definitions are consistently and accurately applied. [AII]					
6.	Active surveillance should be used for surveillance programs in hospitals and long-term care homes because of the higher sensitivity associated with this approach to case finding. [AII]					
7.	Rates of health care-associated infection for patient/resident length of stay should be adjusted by using the number of patient/resident days as the denominator, rather than number of admissions or number of beds. [BIII]					
8.	Rates of surgical site infection in patients undergoing the same surgical procedure should be calculated. Strategies should also be developed to detect surgical site infections post-discharge. There is no generally accepted method for conducting post-discharge surveillance outside the hospital setting. [AIII]					
9.	Rates of device-associated infection that are adjusted for duration of exposure to the device should be calculated. [AII]					
10.	When collecting data for the denominator for device-associated infection rates, data should be collected on the length of time that each patient/resident was exposed to a particular device, rather than the total number of days that all patients were exposed to the device. [AII]					
11.	Electronic systems to store data and assist with the calculation of HAI rates should be used in health care settings. [AII]					
12.	Rates of procedure-specific surgical site infections should be stratified by wound class. [AII]					
13.	A colleague should review HAI rates and check their accuracy prior to any interpretation of the rate. [BIII]					
14.	The possibility that differences in rates of infection in your facility from previous surveillance periods may be the result of changes in institutional practices or surveillance practices should be explored. [AIII]					

Recommendation		Compliant	Partial Compliance	Non-compliant	Action Plan	Accountability
15.	A set of peer institutions should be identified that use the same case definitions and similar case finding methods to serve as a comparison group. When comparing HAI rates to those of other hospitals or long-term care homes, an ICP should consider the surveillance methods used by these facilities. [AII]					
16.	If the Infection Control Team finds that an elevated HAI rate represents an increased risk of infection, they should use a conceptual framework (such as the Chain of Transmission model) to suggest explanations for these rates and areas where improvements to infection control practices could reduce the rates. [AII]					
17.	Communication of surveillance data should take place on an ongoing, systematic basis and be targeted to those with the ability to change infection control practice. All surveillance reports should be clear and easy to follow, including the use of visual aids including pie charts, bar charts and graphs. [AII]					
18.	The surveillance process implemented in a facility (e.g., application of case definitions, case finding and communication methods) should be regularly reviewed and modifications made as needed. At least annually, the outcomes of surveillance systems (i.e., reductions to the risk of infection) should be reviewed and system objectives re-aligned as required. [AIII]					

IV. Appendices

Appendix A: Ranking System for Recommendations

Categories for strength of each recommendation	
CATEGORY	**DEFINITION**
A	Good evidence to support a recommendation for use.
B	Moderate evidence to support a recommendation for use.
C	Insufficient evidence to support a recommendation for or against use
D	Moderate evidence to support a recommendation against use.
E	Good evidence to support a recommendation against use.
Categories for quality of evidence on which recommendations are made	
GRADE	**DEFINITION**
I	Evidence from at least one properly randomized, controlled trial.
II	Evidence from at least one well-designed clinical trial without randomization, from cohort or case-controlled analytic studies, preferably from more than one centre, from multiple time series, or from dramatic results in uncontrolled experiments.
III	Evidence from opinions of respected authorities on the basis of clinical experience, descriptive studies, or reports of expert committees.

Appendix B: Evidence for the Effectiveness of Surveillance Systems in Reducing Health Care-Associated Infections

Search strategies were developed and executed in MEDLINE (1945-2013) to identify all English language studies that investigated whether the establishment of a surveillance system was associated with a decrease in the rate of health care-associated infections (HAIs). Combinations of the search terms indicated below initially yielded 317 studies. Subsequent review of the abstracts from the electronic records and of reference lists identified 14 studies that examined a change in the rate of HAIs following establishment of a surveillance system in a hospital or long-term care home.

Search Terms Used to Identify Studies for Subsequent Review

- Nosocomial infection.mp. or cross-infection
- Long-term care
- Health-care acquired
- Sentinel surveillance/ or population surveillance
- Surgical wound Infection/ or surgical site infection.mp. / or surveillance.mp
- Urinary tract infections
- Pneumonia/ or ventilator-associated
- Drug resistance, Multiple/ or Drug Resistance, Microbial
- Catheterization, central venous
- Evaluation studies
- Effectiveness
- Cost benefit analysis
- Benchmarking
- Practice guidelines/ or best practices

The studies that were identified were then assessed with respect to two main evaluative criteria:

1. Adjustment for case mix factors. Studies were assessed by whether they controlled for potential differences in the risk of HAIs that could have explained any changes in HAI rates prior to, and following, the establishment of surveillance systems.

2. Identifiable impact of the surveillance system. An examination of the mechanisms through which reductions in HAI rates are likely to have resulted are important to the assessment of the contribution of the surveillance system (and/or the changes it brings about) to reduced rates of HAI.

Fifteen studies were identified that examined the impact of surveillance on risk of HAI. The design, populations examined, results and evaluation of each of the 15 studies are summarized in the table below.

Although none of the studies completely met the evaluative criteria, overall this review shows a clear association between development of a system of surveillance and reduction in the risk of HAIs in hospitals. Although none of the studies examined the impact of surveillance systems in long-term care, there is no reason to suggest that similar effects would not be observed in that setting.

Summary of Studies Associating Change in Rates of Health Care-associated Infection with Establishment of a Surveillance System

Study	Summary study design	Key results	Adjustment for case mix factors	Identifiable impact of surveillance
1980, Cruse and Foord[58]	Examined changes in the rates of surgical site infections following implementation of surveillance in two hospitals in Calgary.	Rates declined from 5.8% to 2.5% and from 5.7% to 3.3% of all surgical procedures in each hospital respectively, in the six months following implementation of the surveillance program and reporting of rates.	Analysis was unadjusted for any risk factors for surgical site infection.	Continued decline in rates of surgical site infections were observed following implementation of infection control practices informed by surveillance system.
1985, Haley et al.[15]	Compared rates of surgical site infections, urinary tract infections, pneumonias and bacteraemia in a nationally representative set of U.S. hospitals prior to, and following, the establishment of surveillance systems.	Hospitals that established strong systems of infection and control and surveillance experienced reduction in rates of HAIs ranging from 7-50%, depending on the type of infection.	Analysis controlled for several patient and procedure-related risk factors for HAIs.	Study identified specific surveillance system components associated with a decline in the rates of HAI.
1990, Olson and Lee[53]	Single institution study examining changes in surgical site infections over a 10-year period.	Rates of surgical site infection declined significantly from the index year, from 4.2% of operative procedures to approximately 2%, sustained over the study period.	Rates were adjusted for wound class only.	No changes in infection control practices coincided with implementation of the surveillance program.
2000, Mintjes-de Groot et al.[51]	Single institution study in the Netherlands that examined rates of urinary tract infections, surgical site infections, lower respiratory tract infections and bacteraemia over a 13-year period.	Forty per cent reduction in overall rate of surgical site infections over the study period.	No adjustment for case mix factors that could have influenced rates of infection over time.	The authors' explain that the identification of two high risk areas (general surgery and orthopaedics) through the surveillance system, with subsequent targeting in infection control, drove the decline in rates of infection.

Study	Summary study design	Key results	Adjustment for case mix factors	Identifiable impact of surveillance
2000, CDC NNIS[168]	Report on the U.S. National Nosocomial Infections Surveillance (NNIS) program spanning 10 years of hospital surveillance (1990-1999), including HAI rates measured during the surveillance period.	Reduction in HAI rates in hospitals during the surveillance period attributed to ICPs who use monitoring data to implement prevention activities.	Surgical procedures were adjusted for risk factors.	This program demonstrated the value of NNIS as a model to reduce HAIs in U.S. hospitals.
2002, Gastmeier et al.[52]	Examined the effect of infection control working groups and systems of surveillance on the occurrence of HAIs (surgical site infections, urinary tract infections, lower respiratory tract infections, bloodstream infections) in German hospitals. The frequency of infection was compared to a group of hospitals in which no intervention took place.	The establishment of surveillance systems in intervention hospitals, after infection control working groups were operational, did not result in an additional reduction in HAI.	Analysis was unadjusted for any risk factors for several case mix factors.	The continued presence of the study staff in both intervention and control hospitals may have produced a "surveillance effect", making additional impacts of surveillance difficult to detect.
2002, Merle[59]	Single facility study examining change in urinary tract infections (UTI) associated with surveillance in France.	The proportion of patients developing a UTI was reduced from approximately 14% to 12% of catheterized patients.	Analysis was unadjusted for any risk factors for UTI.	No specific changes to infection control practices were explained.
2005, Sykes et al.[56]	Examined changes in the rate of surgical site infection following interruption of a surveillance program in a single hospital.	Rates of HAI increased to pre-surveillance levels following interruption of the surveillance program.	Rates were not adjusted by any patient risk factors.	No changes to infection control practices over the period of interruption were mentioned.

Study	Summary study design	Key results	Adjustment for case mix factors	Identifiable impact of surveillance
2006, Brandt et al.[54]	Examined changes in the rates of surgical site infections in the period following surveillance among hospitals participating in the German national surveillance program.	Surgical site infections were reduced by 25% following implementation of the surveillance program.	Analysis adjusted for several patient and procedural-related risk factors.	No changes to infection control practices are discussed.
2006, Barwolff et al.[57]	Examined changes in the rates of surgical site infections associated with Caesarean delivery associated with participation in the German national nosocomial surveillance program.	An approximate 40% reduction in surgical site infections was observed following implementation of the program.	Analysis adjusted for several patient and procedural-related risk actors.	Increased awareness of infection control practices, resulting from the surveillance program, was thought to be responsible for the decline in rates of surgical site infections.
2006, Geubbels et al.[55]	Examined changes in the rates of surgical site infections in the period following surveillance among hospitals participating in the Dutch national surveillance program.	Surgical site infections were reduced by approximately 60% for five years following implementation of the surveillance program.	Analysis adjusted for several patient and procedural-related risk factors.	Infection control measures informed by the information generated by the surveillance programs are thought to be an underlying factor in the continued decline in rate of infection.
2006, 2008, Gastmeier et al.[50, 60]	Examined the reduction in the rates of ventilator-associated pneumonias, central venous catheter-related bloodstream infections and surgical site infections in hospitals following implementation of the German National Nosocomial Infection Surveillance system.	Following implementation of surveillance system, an approximate 30% decrease in the rate of pneumonias and surgical site infections and 20% reduction in bloodstream infections was observed.	Data on other risk factors for infection was only available for surgical site infections.	While the authors note no overall changes in national hospital care practices during the study period, investigators could not take into account infection control practices in individual participating hospitals.

Study	Summary study design	Key results	Adjustment for case mix factors	Identifiable impact of surveillance
2009, Daneman et al.[63]	Retrospective cohort study in Ontario, Canada to validate the NNIS system risk index to predict surgical site infections, using administrative data.	The modified NNIS surgical risk index predicted increases in surgical site infection risk within 11 surgical subgroups.	Data was only collected on elderly patients who underwent elective surgery. Procedures were classified by a modified NNIS index.	The modified NNIS surgical risk stratification index was associated with a significant elevation of predicted risk for wound infection rates.
2012, Mabit et al.[61]	Tested the hypothesis that there is a correlation between creating a SSI surveillance program and a reduction in SSI, using SSI surveillance data from the end of 2009 to the end of 2011 of one hospital.	Since the end of 2009, 7,156 surgical procedures were evaluated (rate of inclusion 97.3%), and 84 SSI were registered with a significant decrease over time from 1.86% to 0.66%.	Results applied to orthopedics and traumatology only. Procedures were classified by the NNIS index.	Receiving retro-information was systematically correlated to a downturn in the curve for the occurrence of SSI.
2012, Daneman et al.[63]	Retrospective, longitudinal population-based cohort study in Ontario, Canada to determine whether mandatory public reporting by hospitals is associated with a reduction in hospital rates of *Clostridium difficile* infection.	With the introduction of public reporting, *C. difficile* infections declined by 26% across Ontario, resulting in over 1,900 cases averted per year.	Data was adjusted by age group and hospital type.	Public reporting of hospital *C. difficile* infection rates was associated with a substantial reduction in the burden of infection.

Appendix C: Recommended Case Definitions for Surveillance of Health Care-Associated Infections in Hospitals

In 2013 the National Healthcare Safety Network (NHSN) revised many of their surveillance definitions.*For example:

- Surgical site infection (SSI) surveillance has new definitions for 'primary closure'.
- Ventilator-associated pneumonia (VAP) surveillance has been changed to surveillance for ventilator-associated events (VAE).
- Central line-associated bloodstream infection (CLABSI) has new criteria for differentiating between primary or secondary BSI.

The advantage to using the revised NHSN definitions is that data can be compared with U.S. figures, which are accepted and used internationally. For benchmarking purposes, NHSN surveillance definitions are preferred. Where mandatory reporting of specific types of infections has been instituted, those definitions may be used alone or in addition to NHSN definitions.

*Source: U.S. Centers for Disease Control and Prevention, National Healthcare Safety Network (NHSN),[162] available at: www.cdc.gov/nhsn/PDFs/pscManual/17pscNosInfDef_current.pdf.

A. BLOODSTREAM INFECTION (BSI)

I. Laboratory-confirmed Bloodstream Infection (LCBI)

Must meet *one* of the following criteria:

Criterion 1: Patient has a recognized pathogen cultured from one or more blood cultures
AND
Organism cultured from blood is not related to an infection at another site.

Criterion 2: Patient has *at least one* of the following signs or symptoms:

a) fever (>38°C), chills, or hypotension
OR

b) positive laboratory results are not related to an infection at another site
OR

c) the same common commensal (i.e., diphtheroids [*Corynebacterium* spp. not *C. diphtheriae*], *Bacillus* spp. [not *B. anthracis*], *Propionibacterium* spp., coagulase-negative staphylococci [including *S. epidermidis*], viridans group streptococci, *Aerococcus* spp., and *Micrococcus* spp.) is cultured from two or more blood cultures drawn on separate occasions. Criterion elements must occur within a timeframe that does not exceed a gap of one calendar day between two adjacent elements.

Criterion 3: Patient ≤ 1 year of age has *at least one* of the following signs or symptoms:

a) fever (>38°C core), hypothermia (<36°C core), apnea, or bradycardia
OR

b) positive laboratory results are not related to an infection at another site
OR

c) the same common commensal (i.e., diphtheroids [*Corynebacterium* spp. not *C. diphtheriae*], *Bacillus* spp. [not *B. anthracis*], *Propionibacterium* spp., coagulase-negative staphylococci [including *S. epidermidis*], viridans group streptococci, *Aerococcus* spp., *Micrococcus* spp.) is cultured from two or more blood cultures drawn on the same or consecutive days and separate occasions. Criterion elements must occur within a timeframe that does not exceed a gap of one calendar day between two adjacent elements.

II. Mucosal Barrier Injury Laboratory-confirmed Bloodstream Infection (MBI-LCBI)

Must meet *one* of the following criteria:

Criterion 1: Patient of any age meets Criterion 1 for LCBI with at least one blood culture growing any of the following intestinal organisms with no other organisms isolated: *Bacteroides* spp., *Candida* spp., *Clostridium* spp., *Enterococcus* spp., *Fusobacterium* spp., *Peptostreptococcus* spp., *Prevotella* spp., *Veillonella* spp., or *Enterobacteriaceae*

AND

Patient meets *at least one* of the following:

a) Is an allogeneic hematopoietic stem cell transplant recipient within the past year with one of the following documented during same hospitalization as positive blood culture:
   i) Grade III or IV gastrointestinal graft versus host disease (GVHD)
   ii) ≥1 litre diarrhea in a 24-hour period (or ≥20 mL/kg in a 24-hour period for patients <18 years of age) with onset on or within seven calendar days before the date the positive blood culture was collected

OR

b) Is neutropenic, defined as at least two separate days with values of absolute neutrophil count (ANC) or total white blood cell count (WBC) <500 cells/mm^3 within a seven-day time period, which includes the date the positive blood culture was collected (Day 1), the three calendar days before and the three calendar days after.

Criterion 2: Patient of any age meets Criterion 2 for LCBI when the blood cultures are growing only viridans group streptococci with no other organisms isolated

AND

Patient meets *at least one* of the following:

a) Is an allogeneic hematopoietic stem cell transplant recipient within the past year with *one of the following* documented during same hospitalization as positive blood culture:
   i) Grade III or IV gastrointestinal graft versus host disease (GVHD)
   ii) ≥1 litre diarrhea in a 24-hour period (or ≥20 mL/kg in a 24-hour period for patients <18 years of age) with onset on or within seven calendar days before the date the first positive blood culture was collected

OR

b) Is neutropenic, defined as at least two separate days with values of absolute neutrophil count (ANC) or total white blood cell count (WBC) <500 cells/mm^3 within a seven-day time period which includes the date the positive blood culture was collected (Day 1), the three calendar days before and the three calendar days after.

Criterion 3: Patient ≤1 year of age meets Criterion 3 for LCBI when the blood cultures are growing only viridans group streptococci with no other organisms isolated

AND

Patient meets *at least one* of the following:

a) Is an allogeneic hematopoietic stem cell transplant recipient within the past year with *one of the following* documented during same hospitalization as positive blood culture:
   i) Grade III or IV gastrointestinal graft versus host disease (GVHD)
   ii) ≥20 mL/kg diarrhea in a 24-hour period with onset on or within seven calendar days before the date the first positive blood culture is collected

OR

b) Is neutropenic, defined as at least two separate days with values of absolute neutrophil count (ANC) or total white blood cell count (WBC) <500 cells/mm^3 within a seven-day time period which includes the date the positive blood culture was collected (Day 1), the three calendar days before and the three calendar days after.

B. VENTILATOR-ASSOCIATED EVENT (VAE)

I. Ventilator-Associated Condition (VAC)

Patient has a baseline period of stability or improvement on the ventilator, defined by two or more calendar days of stable or decreasing daily minimum FiO_2 or PEEP values. The baseline period is defined as the two calendar days immediately preceding the first day of increased daily minimum PEEP or FiO_2

AND

After a period of stability or improvement on the ventilator, the patient has *at least one* of the following indicators of worsening oxygenation:

a) Increase in daily minimum* FiO_2 of ≥ 0.20 (20 points) over the daily minimum FiO_2 in the baseline period, sustained for two or more calendar days

OR

b) Increase in daily minimum* PEEP values of ≥ 3 cm H_2O over the daily minimum PEEP in the baseline period†, sustained for two or more calendar days

*Daily minimum defined by lowest value of FiO_2 or PEEP during a calendar day that is maintained for at least one hour.

†Daily minimum PEEP values of 0-5 cm H_2O are considered equivalent for the purposes of VAE surveillance.

II. Infection-related Ventilator-Associated Complication (IVAC)

Patient meets criteria for VAC

AND

On or after calendar day three of mechanical ventilation and within two calendar days before or after the onset of worsening oxygenation, the patient meets *both* of the following criteria:

a) Temperature > 38°C or < 36°C, OR white blood cell count ≥ 12,000 cells/mm^3 or ≤ 4,000 cells/mm^3.

AND

b) A new antimicrobial agent(s) is started, and is continued for four or more calendar days.

III. Possible Ventilator-Associated Pneumonia

Patient meets criteria for VAC and IVAC

AND

On or after calendar day three of mechanical ventilation and within two calendar days before or after the onset of worsening oxygenation, *ONE* of the following criteria is met:

a) Purulent respiratory secretions (from one or more specimen collections)
   - Defined as secretions from the lungs, bronchi, or trachea that contains > 25 neutrophils and < 10 squamous epithelial cells per low power field [lpf, x100].
   - If the laboratory reports semi-quantitative results, those results must be equivalent to the above quantitative thresholds.
   - See additional instructions for using the purulent respiratory secretions criterion in the VAE Protocol.

OR

b) Positive culture (qualitative, semi-quantitative or quantitative) of sputum*, endotracheal aspirate*, bronchoalveolar lavage*, lung tissue, or protected specimen brushing*.

*Excludes the following:

- Normal respiratory/oral flora, mixed respiratory/oral flora or equivalent
- Candida species or yeast not otherwise specified
- Coagulase-negative Staphylococcus species
- Enterococcus species

IV. Probable Ventilator-Associated Pneumonia

Patient meets criteria for VAC and IVAC

AND

On or after calendar day three of mechanical ventilation and within two calendar days before or after the onset of worsening oxygenation, *ONE* of the following criteria is met:

a) Purulent respiratory secretions (from one or more specimen collections—and defined as for possible VAP)

AND

ONE of the following:

i) Positive culture of endotracheal aspirate*, ≥ 10^5 CFU/ml or equivalent semi-quantitative result
ii) Positive culture of bronchoalveolar lavage*, ≥ 10^4 CFU/ml or equivalent semi-quantitative result
iii) Positive culture of lung tissue, ≥ 10^4 CFU/g or equivalent semi-quantitative result
iv) Positive culture of protected specimen brush*, ≥ 10^3 CFU/ml or equivalent semi-quantitative result

*Same organism exclusions as noted for Possible VAP.

OR

b) *ONE* of the following (without requirement for purulent respiratory secretions):
i) Positive pleural fluid culture (where specimen was obtained during thoracentesis or initial placement of chest tube and NOT from an indwelling chest tube)
ii) Positive lung histopathology
iii) Positive diagnostic test for Legionella spp.
iv) Positive diagnostic test on respiratory secretions for influenza virus, respiratory syncytial virus, adenovirus, parainfluenza virus, rhinovirus, human metapneumovirus, coronavirus

C. URINARY TRACT INFECTION (UTI)

I. Symptomatic Urinary Tract Infection (SUTI)

Must meet *at least one* of the following criteria:

Criterion 1a:

Patient had an indwelling urinary catheter in place for >2 calendar days, with day of device placement being Day 1, and catheter was in place on the date of event

AND

Patient has *at least one* of the following signs or symptoms: fever (>38°C); suprapubic tenderness*; costovertebral angle pain or tenderness*

AND

Patient has a positive urine culture of ≥10^5 colony-forming units (CFU)/mL with no more than two species of microorganisms. Elements of the criterion must occur within a timeframe that does not exceed a gap of one calendar day between two adjacent elements.

* with no other recognized cause

OR

Patient had an indwelling urinary catheter in place for >2 calendar days and had it removed the day of or the day before the date of event

AND

Patient has *at least one* of the following signs or symptoms: fever (>38°C); urgency*; frequency*; dysuria*; suprapubic tenderness*; costovertebral angle pain or tenderness*

AND

Patient has a positive urine culture of ≥10^5 colony-forming units (CFU)/mL with no more than two species of microorganisms. Elements of the criterion must occur within a timeframe that does not exceed a gap of one calendar day between two adjacent elements.

* with no other recognized cause

Criterion 1b:

Patient did not have an indwelling urinary catheter that had been in place for >2 calendar days and in place at the time of or the day before the date of event

AND

Patient has *at least one* of the following signs or symptoms: fever (>38°C) in a patient that is ≤65 years of age; urgency*; frequency*; dysuria*; suprapubic tenderness*; costovertebral angle pain or tenderness*

AND

Patient has a positive urine culture of $\geq 10^5$ CFU/mL with no more than two species of microorganisms. Elements of the criterion must occur within a timeframe that does not exceed a gap of one calendar day between elements two adjacent elements.

*with no other recognized cause

Criterion 2a:

Patient had an indwelling urinary catheter in place for >2 calendar days, with day of device placement being Day 1, and catheter was in place on the date of event

AND

Patient has *at least one* of the following signs or symptoms: fever (>38°C); suprapubic tenderness*; costovertebral angle pain or tenderness*

AND

Patient has *at least one* of the following findings:

a) positive dipstick for leukocyte esterase and/or nitrite
b) pyuria (urine specimen with ≥10 white blood cells [WBC]/mm^3 of unspun urine or >5 WBC/high power field of spun urine)
c) microorganisms seen on Gram's stain of unspun urine

AND

Patient has a positive urine culture of $\geq 10^3$ and $<10^5$ CFU/mL with no more than two species of microorganisms. Elements of the criterion must occur within a timeframe that does not exceed a gap of one calendar day between two adjacent elements.

OR

Patient with an indwelling urinary catheter in place for >2 calendar days and had it removed the day of or the day before the date of event

AND

Patient has *at least one* of the following signs or symptoms: fever (>38°C); urgency*; frequency*; dysuria*; suprapubic tenderness*; costovertebral angle pain or tenderness*

AND

Patient has *at least one* of the following findings:

a) positive dipstick for leukocyte esterase and/or nitrite
b) pyuria (urine specimen with ≥10 WBC/mm^3 of unspun urine or >5 WBC/high power field of spun urine
c) microorganisms seen on Gram's stain of unspun urine

AND

Patient has a positive urine culture of $\geq 10^3$ and $<10^5$ CFU/ml with no more than two species of microorganisms. Elements of the criterion must occur within a timeframe that does not exceed a gap of one calendar day between two adjacent elements.

*with no other recognized cause

Criterion 2b:

Patient did not have an indwelling urinary catheter, that had been in place for >2 calendar days and in place at the time of, or the day before the date of event

AND

Patient has *at least one* of the following signs or symptoms: fever (>38°C) in a patient that is ≤65 years of age; urgency*; frequency*; dysuria*; suprapubic tenderness*; costovertebral angle pain or tenderness*

AND

Patient has *at least one* of the following findings:

a) positive dipstick for leukocyte esterase and/or nitrite
b) pyuria (urine specimen with ≥10 WBC/mm^3 of unspun urine or >5 WBC/high power field of spun urine

c) microorganisms seen on Gram's stain of unspun urine

AND

Patient has a positive urine culture of ≥10^3 and <10^5 CFU/mL with no more than two species of microorganisms. Elements of the criterion must occur within a timeframe that does not exceed a gap of one calendar day between two adjacent elements.

*With no other recognized cause

Criterion 3:

Patient ≤1 year of age with an indwelling urinary catheter in place for >2 calendar days (with day of device placement being Day 1 and catheter was in place on the date of event) or without an indwelling urinary catheter has *at least one* of the following signs or symptoms: fever (>38°C core); hypothermia (<36°C core); apnea*; bradycardia*; dysuria*; lethargy*; vomiting*

AND

Patient has a positive urine culture of ≥10^5 CFU/ml with no more than two species of microorganisms. Elements of the criterion must occur within a timeframe that does not exceed a gap of one calendar day between two adjacent elements.

*with no other recognized cause

Criterion 4:

Patient ≤1 year of age with an indwelling urinary catheter in place for >2 calendar days (with day of device placement being Day 1 and catheter was in place on the date of event) or without an indwelling urinary catheter has *at least one* of the following signs or symptoms: fever (>38°C core); hypothermia (<36°C core); apnea*; bradycardia*; dysuria*; lethargy*; vomiting*

AND

Patient has *at least one* of the following findings:

a) positive dipstick for leukocyte esterase and/or nitrite
b) pyuria (urine specimen with ≥10 WBC/mm^3 of unspun urine or >5 WBC/high power field of spun urine
c) microorganisms seen on Gram's stain of unspun urine

AND

Patient has a positive urine culture of between ≥10^3 and <10^5 CFU/mL with no more than two species of microorganisms. Elements of the criterion must occur within a timeframe that does not exceed a gap of one calendar day between two adjacent elements.

*with no other recognized cause

II. Asymptomatic Bacteremic Urinary Tract Infection (ABUTI)

Patient with an indwelling urinary catheter in place for >2 calendar days (with day of device placement being Day 1 and catheter was in place on the date of event) or without an indwelling urinary catheter has no signs or symptoms (i.e., for any age patient, no fever (>38°C); urgency; frequency; dysuria; suprapubic tenderness; costovertebral angle pain or tenderness; **OR** for a patient ≤1 year of age, no hypothermia (<36°C core); apnea; bradycardia; dysuria; lethargy; or vomiting)

AND

Patient has a positive urine culture of ≥10^5 CFU/ml with no more than two species of uropathogen microorganisms (Gram-negative bacilli, *Staphylococcus* spp., yeasts, beta-hemolytic *Streptococcus* spp., *Enterococcus* spp., *G. vaginalis*, *Aerococcus urinae*, and *Corynebacterium* (urease positive)

AND

Patient has a positive blood culture with at least one matching uropathogen microorganism to the urine culture, or at least two matching blood cultures drawn on separate occasions if the matching pathogen is a common skin commensal. Elements of the criterion must occur within a timeframe that does not exceed a gap of one calendar day between two adjacent elements.

D. SURGICAL SITE INFECTIONS (SSI)

I. Superficial Incisional SSI

Infection occurs within 30 days after operative procedure

AND

Infection involves only skin and subcutaneous tissue of the incision

AND

Patient has *at least one* of the following:

a) purulent drainage from the superficial incision
b) organisms isolated from an aseptically-obtained culture of fluid or tissue from the superficial incision
c) superficial incision that is deliberately opened by a surgeon, attending physician** or other designee *and* is culture-positive or not cultured
   AND
   patient has *at least one* of the following signs or symptoms of infection: pain or tenderness; localized swelling; redness; or heat; a culture-negative finding does not meet this criterion.
d) diagnosis of superficial incisional SSI by the surgeon or attending physician** or other designee.

** The term attending physician for the purposes of application of the NHSN SSI criteria may be interpreted to mean the surgeon(s), infectious disease, other physician on the case, emergency physician or physician's designee (nurse practitioner or physician's assistant).

Reporting Instructions:

1. The following do not qualify as criteria for meeting the NHSN definition of superficial SSI:
   - A stitch abscess alone (minimal inflammation and discharge confined to the points of suture penetration)
   - A localized stab wound or pin site infection.
   - Diagnosis of "cellulitis", by itself, does not meet criterion (d) for superficial incisional SSI.
   - Circumcision is not an NHSN operative procedure; an infected circumcision site in newborns is classified as CIRC and is not reportable under this module.
   - An infected burn wound is classified as BURN and is not reportable under this module.
2. Report infection that involves the organ/space as an organ/space SSI, whether or not it also involves the superficial or deep incision sites.
3. Report infection that involves the superficial and deep incisional sites as a deep incisional SSI.

II. Deep Incisional SSI

Infection occurs within 30 or 90 days after the NHSN operative procedure

AND

Infection involves deep soft tissues of the incision (e.g., fascial and muscle layers)

AND

Patient has *at least one* of the following:

a) purulent drainage from the deep incision
b) a deep incision that spontaneously dehisces or is deliberately opened by a surgeon, attending physician** or other designee and is culture-positive or not cultured
   AND
   patient has *at least one* of the following signs or symptoms: fever (>38°C); localized pain or tenderness; a culture-negative finding does not meet this criterion
c) an abscess or other evidence of infection involving the deep incision that is detected on direct examination, during invasive procedure, or by histopathologic examination or imaging test.

** The term attending physician for the purposes of application of the NHSN SSI criteria may be interpreted to mean the surgeon(s), infectious disease, other physician on the case, emergency physician or physician's designee (nurse practitioner or physician's assistant).

Reporting Instructions:

The type of SSI (superficial incisional, deep incisional, or organ/space) reported should reflect the deepest tissue layer involved in the infection:

- Report infection that involves the organ/space as an organ/space SSI, whether or not it also involves the superficial or deep incision sites.
- Report infection that involves the superficial and deep incisional sites as a deep incisional SSI.

III. Organ/Space SSI

Infection occurs within 30 or 90 days after the operative procedure, according to the procedure [procedures grouped accordingly]

AND

Infection involves any part of the body, excluding the skin incision, fascia, or muscle layers, that is opened or manipulated during the operative procedure

AND

Patient has *at least one* of the following:

a) purulent drainage from a drain that is placed into the organ/space
b) organisms isolated from an aseptically-obtained culture of fluid or tissue in the organ/space
c) an abscess or other evidence of infection involving the organ/space that is detected on direct examination, during invasive procedure, or by histopathologic examination or imaging test

AND

Meets *at least one* criterion for a specific organ/space infection site (see box below for list of sites)

Reporting Instructions:

If a patient has an infection in the organ/space being operated on, subsequent continuation of this infection type during the remainder of the surveillance period is considered an organ/space SSI, if organ/space SSI and site-specific infection criteria are met.

Specific Sites of an Organ/Space SSI

CODE	SITE	CODE	SITE
BONE	Osteomyelitis	LUNG	Other infections of the respiratory tract
BRST	Breast abscess or mastitis	MED	Mediastinitis
CARD	Myocarditis or pericarditis	MEN	Meningitis or ventriculitis
DISC	Disc space	ORAL	Oral cavity (mouth, tongue, or gums)
EAR	Ear, mastoid	OREP	Other infections of the male or female reproductive tract
EMET	Endometritis	OUTI	Other infections of the urinary tract
ENDO	Endocarditis	PJI	Periprosthetic Joint Infection
EYE	Eye, other than conjunctivitis	SA	Spinal abscess without meningitis
GIT	GI tract	SINU	Sinusitis
HEP	Hepatitis	UR	Upper respiratory tract
IAB	Intra-abdominal, not specified elsewhere	VASC	Arterial or venous infection
IC	Intracranial, brain abscess or dura	VCUF	Vaginal cuff
JNT	Joint or bursa		

Specific Sites of an Organ/Space SSI

CODE	SITE	CODE	SITE
BONE	Osteomyelitis	LUNG	Other infections of the respiratory tract
BRST	Breast abscess or mastitis	MED	Mediastinitis
CARD	Myocarditis or pericarditis	MEN	Meningitis or ventriculitis
DISC	Disc space	ORAL	Oral cavity (mouth, tongue, or gums)
EAR	Ear, mastoid	OREP	Other infections of the male or female reproductive tract
EMET	Endometritis	OUTI	Other infections of the urinary tract
ENDO	Endocarditis	PJI	Periprosthetic Joint Infection
EYE	Eye, other than conjunctivitis	SA	Spinal abscess without meningitis
GIT	GI tract	SINU	Sinusitis
HEP	Hepatitis	UR	Upper respiratory tract
IAB	Intra-abdominal, not specified elsewhere	VASC	Arterial or venous infection
IC	Intracranial, brain abscess or dura	VCUF	Vaginal cuff
JNT	Joint or bursa		

Appendix D: Recommended Case Definitions for Surveillance of Health Care-Associated Infections in Long-term Care Homes

NOTE: Long-term care surveillance definitions in previous versions of this document were originally published by McGeer et al.[93] in 1991. A current re-visitation of these definitions has been proposed by Stone et al.[94] in 2012, and are summarized in this Appendix.

A. RESPIRATORY TRACT INFECTION

I. Common Cold Syndromes/Pharyngitis

The resident must have *at least two* of the following signs or symptoms:

1. runny nose or sneezing
2. stuffy nose (i.e., congestion)
3. sore throat or hoarseness or difficulty in swallowing
4. dry cough
5. swollen or tender glands in the neck (cervical lymphadenopathy).

Comment:

Fever may or may not be present. Symptoms must be new, and care must be taken to ensure that they are not caused by allergies.

II. Influenza-like Illness (ILI)

Both of the following criteria must be met:

1. Fever (see Comments)

   AND

2. The resident must have *at least three* of the following signs or symptoms:
   a) chills
   b) new headache or eye pain
   c) myalgias or body aches
   d) malaise or loss of appetite
   e) sore throat
   f) new or increased dry cough.

Comments:

If criteria for influenza-like illness and another upper or lower respiratory tract infection are met at the same time, only the diagnosis of influenza-like illness should be recorded.

Because of increasing uncertainty surrounding the timing of the start of influenza season, the peak of influenza activity, and the length of the season, "seasonality" is no longer a criterion to define influenza-like illness.

Fever:

- single oral temperature >37.8° C
  OR
- repeated oral temperatures >37.2° C or rectal temperatures >37.5° C
  OR
- single temperature >1.1° C over baseline from any site (oral, tympanic, axillar)

III. Pneumonia

All three of the following criteria must be met:

1. Interpretation of a chest radiograph as demonstrating pneumonia, or the presence of a new infiltrate.
   AND
2. The resident must have *at least one* of the following:
   a) new or increased cough
   b) new or increased sputum production
   c) O_2 saturation <94% on room air or a reduction in O_2 saturation of >3% from baseline
   d) new or changed lung examination abnormalities
   e) pleuritic chest pain
   f) respiratory rate of ≥ 25 breaths/minute
   AND
3. *At least one* of the following constitutional criteria (see box):
   a) fever
   b) leukocytosis
   c) acute change in mental status from baseline
   d) acute functional decline

Comments:

Non-infectious causes of symptoms must be ruled out. In particular, congestive heart failure or interstitial lung disease may produce symptoms and signs similar to those of respiratory infections.

Constitutional Criteria:

Fever:

- single oral temperature >37.8° C
  OR
- repeated oral temperatures >37.2° C or rectal temperatures >37.5° C
  OR
- single temperature >1.1° C over baseline from any site (oral, tympanic, axillar)

Leukocytosis:

- neutrophilia (>14,000 leukocytes/mm^3)
  OR
- left shift (>6% bands or ≥1,500 bands/mm^3

Acute change in mental status from baseline (all criteria must be present):

- acute onset
- fluctuating course
- inattention
  AND
- either disorganized thinking or altered level of consciousness

Acute functional decline: A new 3-point increase in total activities of daily living score from baseline, based on the following seven items, each scored from 0 (independent) to 4 (total dependence):

- bed mobility
- transfer
- locomotion within the long-term care home
- dressing
- toilet use
- personal hygiene
  eating

IV. Lower Respiratory Tract Infection (bronchitis, tracheobronchitis)

The resident must have *all three* of the following signs or symptoms:

a) Chest radiograph not performed or negative results for pneumonia or new infiltrate
   AND
b) *At least two* of the following respiratory criteria:
   i) new or increased cough
   ii) new or increased sputum production
   iii) O_2 saturation <94% on room air or a reduction in O_2 saturation of >3% from baseline
   iv) new or changed lung examination abnormalities

v) pleuritic chest pain
vi) respiratory rate of ≥ 25 breaths/minute

AND

c) *At least one* of the constitutional criteria listed in box, Section A.III, above

Comments:

Non-infectious causes of symptoms must be ruled out. In particular, congestive heart failure or interstitial lung disease may produce symptoms and signs similar to those of respiratory infections.

See box, Section A.III for additional comments relating to respiratory and constitutional criteria.

B. URINARY TRACT INFECTION (UTI)

Urinary tract infection includes only symptomatic urinary tract infections. Surveillance for asymptomatic bacteriuria (defined as the presence of a positive urine culture in the absence of new signs and symptoms of urinary tract infection) is not recommended, as this represents baseline status for many residents.

Symptomatic Urinary Tract Infection

Indwelling catheter NOT present

Both of the following criteria must be met:

1. The resident has *at least one* of the following signs and symptoms:
   a) Acute dysuria or acute pain, swelling, or tenderness of the testes, epididymis, or prostate

   OR

   b) Fever or leukocytosis (see Box, above) and *at least one* of the following:
      i) acute costovertebral angle pain or tenderness
      ii) suprapubic pain
      iii) gross hematuria
      iv) new or marked increase in incontinence
      v) new or marked increase in urgency
      vi) new or marked increase in frequency

   OR

   c) In the absence of fever or leukocytosis, *two or more* of the following are present:
      i) suprapubic pain
      ii) gross haematuria
      iii) new or marked increase in incontinence
      iv) new or marked increase in urgency
      v) new or marked increase in frequency

   AND

2. The resident has *one* of the following microbiologic criteria:
   a) At least 10^5 cfu/mL of no more than two species of microorganisms in a voided urine sample

   OR

   b) At least 10^2 cfu/mL of any number of organisms in a specimen collected by in-and-out catheter

Indwelling catheter present

Both of the following criteria must be met:

1. The resident has *at least one* of the following signs or symptoms:
   a) Fever, rigors, or new onset hypotension, with no alternate site of infection
   b) Either acute change in mental status or acute functional decline, with no alternate diagnosis, and

leukocytosis (see box, Section A.III)

c) New onset suprapubic pain or costovertebral angle pain or tenderness

d) Purulent discharge from around the catheter or acute pain, swelling, or tenderness of the testes, epididymis, or prostate

AND

2. The resident has a urinary catheter specimen culture with at least 10^5 cfu/mL of any organism

Comments:

UTI should be diagnosed when there are localizing genitourinary signs and symptoms and a positive urine culture result. A diagnosis of UTI can be made without localizing symptoms if a blood culture isolate is the same as the organism isolated from the urine and there is no alternate site of infection. In the absence of a clear alternate source of infection, fever or rigors with a positive urine culture result in the noncatheterized resident or acute confusion in the catheterized resident will often be treated as UTI. However, evidence suggests that most of these epidsodes are likely not due to infection of a urinary source.

Urine specimens for culture should be processed as soon as possible, preferably within one to two hours after collection. If urine specimens cannot be processed within 30 minutes of collection, they should be refrigerated. Refrigerated specimens should be cultured within 24 hours.

Recent catheter trauma, catheter obstruction, or new onset haematuria are useful localizing signs that are consistent with UTI but are not necessary for diagnosis.

Urinary catheter specimens for culture should be collected following replacement of the catheter if the current catheter has been in place for more than 14 days.

C. EYE, EAR, NOSE, AND MOUTH INFECTION

Conjunctivitis

At least one of the following criteria must be present:

1. Pus appearing from one or both eyes, present for at least 24 hours

   OR

2. New or increased conjunctival erythema, with or without itching

   OR

3. New or increased conjunctival pain, present for at least 24 hours

Comments:

Conjunctivitis symptoms (“pink eye”) should not be due to allergic reaction or trauma.

Ear Infection

One of the following criteria must be met:

1. Diagnosis by a physician* of any ear infection

   OR

2. New drainage from one or both ears (non-purulent drainage must be accompanied by additional symptoms, such as ear pain or redness).

* Requires a written note or a verbal report from a physician specifying the diagnosis. Usually implies direct assessment of the resident by a physician. An antibiotic order alone does not fulfill this criterion. In some homes, it may be appropriate also to accept a diagnosis made by other qualified clinicians (e.g., nurse practitioner, physician associate).

Mouth and Perioral Infection

Oral and perioral infections, including oral candidiasis (manifest by the presence of raised white patches on inflamed mucosa or plaques on oral mucosa), must be diagnosed by a physician or a dentist.

Comments:
Mucocutaneous *Candida* infections are usually due to underlying clinical conditions, such as poorly controlled diabetes or severe immunosuppression. Although they are not transmissible infections in the health care setting, they can be a marker for increased antibiotic exposure.

IV. Sinusitis

The diagnosis of sinusitis must be made by a physician.

D. SKIN INFECTION

I. Cellulitis/Soft Tissue/Wound Infection

One of the following criteria must be met:

1. Pus present at a wound, skin, or soft tissue site

   OR

2. The resident must have *at least four* of the following signs or symptoms:
   a) heat at the affected site
   b) redness at the affected site
   c) swelling at the affected site
   d) tenderness or pain at the affected site
   e) serous drainage at the affected site
   f) one constitutional criterion (see box, Section A.III)

Comments:

Presence of organisms cultured from the surface (e.g., superficial swab sample) of a wound is not sufficient evidence that the wound is infected. More than one resident with streptococcal skin infection from the same serogroup in a long-term care home may indicate an outbreak.

II. Fungal Skin Infection

The resident must have *both*:

1. A characteristic rash or lesion

   AND

2. Either physician diagnosis or laboratory confirmation from a scraping or a medical biopsy (see Comments)

Comments:

Dermatophytes have been known to cause occasional infections and rare outbreaks in the long-term care setting.

III. Herpesvirus

For a diagnosis of cold sores (herpes simplex) or shingles (herpes zoster), the resident must have *both*:

1. A vesicular rash

   AND

2. Either physician diagnosis or laboratory confirmation (see Comments).

Comments:

Reactivation of herpes simplex ('cold sores') or herpes zoster ('shingles') is not considered a health care-associated infection. Primary herpesvirus skin infections are very uncommon in a long-term care home.

For herpetic infections, laboratory confirmation includes positive electron microscopy or culture of scraping or swab.

IV. Scabies

The resident must have *both*:

1. A maculopapular and/or itching rash

   AND

2. *At least one* of the following:
   a) physician diagnosis
   b) laboratory confirmation (scraping or biopsy)
   c) epidemiologic linkage to a case of scabies with laboratory confirmation

Comments:

Care must be taken to rule out rashes due to skin irritation, allergic reactions, eczema and other non-infectious skin conditions.

An epidemiologic linkage to a case can be considered if there is evidence of geographic proximity in the facility, temporal relationalship to the onset of symptoms, or evidence of common source of exposure (i.e., shared caregiver).

E. GASTROINTESTINAL (GI) TRACT INFECTION

Gastroenteritis

One of the following criteria must be met:

1. Three or more liquid or watery stools above what is normal for the resident within a 24-hour period

   OR

2. Two or more episodes of vomiting in a 24-hour period

   OR

3. *Both* of the following:
   a) a stool culture positive for a pathogen (e.g., *Salmonella*, *Shigella*, *E. coli O157:H7*, *Campylobacter spp*., rotavirus)

      AND

   b) *at least one* of the following symptoms:
      i) nausea
      ii) vomiting
      iii) abdominal pain or tenderness
      iv) diarrhea

Comments:

Care must be taken to rule out non-infectious causes of symptoms. For instance, new medication may cause both diarrhea and vomiting; nausea and vomiting may be associated with gallbladder disease; initiation of new enteral feeding may be associated with diarrhea. Presence of new GI symptoms in a single resident may prompt enhanced surveillance for additional cases. In the presence of an outbreak, stool specimens should be sent to confirm the presence of norovirus or other pathogens (e.g., rotavirus or *E. coli O157:H7*).

Norovirus Gastroenteritis

Both of the following criteria must be present:

1. *At least one* of the following:
   a) three or more liquid or watery stools above what is normal for the resident within a 24-hour period
   b) two or more episodes of vomiting in a 24-hour period

   AND

2. A stool specimen for which norovirus is positively detected by electron microscopy, enzyme immunoassay, or molecular diagnostic testing, such as polymerase chain reaction (PCR)

Comments:

In the absence of laboratory confirmation, an outbreak (two or more cases occurring in a long-term care home) of acute gastroenteritis due to norovirus infection may be assumed to be present if all of the following criteria are present:

- vomiting in more than half of affected persons
- a mean/median incubation period of 24 to 48 hours
- a mean/median duration of illness of 12 to 60 hours
- no bacterial pathogen is identified in stool culture

Clostridium difficile Infection (CDI)

Both of the following criteria must be present:

1. *At least one* of the following:
   a) three or more liquid or watery stools above what is normal for the resident within a 24-hour period
   b) presence of toxic megacolon (abnormal dilation of the large bowel, documented radiologically)

   AND
2. *At least one* of the following diagnostic criteria:
   a) a stool sample yields a positive laboratory test result for *C. difficile* toxin A or B, or a toxin-producing *C. difficile* organism is identified from a stool sample
   b) pseudomembranous colitis is identified during endoscopic examination or surgery or in histopathologic examination of a biopsy specimen

Comments:

A primary episode of *C. difficile* infection (CDI) is defined as one that has occurred without any previous history of CDI or that has occurred more than eight weeks after the onset of a previous episode.

A recurrent episode of CDI is defined as an episode of CDI that occurs eight weeks or sooner after the onset of a previous episode, provided that the symptoms from the previous episode have resolved.

Individuals previously infected with *C. difficile* may continue to remain colonized even after symptoms resolve. In the setting of an outbreak of CDI, individuals could have positive test results for the presence of *C. difficile* toxin because of ongoing colonization and also be co-infected with another pathogen. It is important that other surveillance criteria be used to differentiate infections in this situation.

F. SYSTEMIC INFECTION

I. Primary Bloodstream Infection

One of the following criteria must be met:

1. Two or more blood cultures positive for the same organism

   OR
2. A single blood culture documented with an organism thought not to be a contaminant and *at least one* of the following:
   a) fever (see box, Section A.III)
   b) new hypothermia (<34.5° C, or does not register on the thermometer being used)
   c) a drop in systolic blood pressure of 30 mm Hg from baseline
   d) worsening mental or functional status.

Comment:

Bloodstream infections related to infection at another site are reported as secondary bloodstream infections and are not included as separate infections.

II. Unexplained Febrile Episode

The resident must have documentation in the medical record of fever (see box, Section A.III) on two or more occasions at least 12 hours apart in any 3-day period, with no known infectious or non-infectious cause.

Appendix E: Sample Sentinel Surveillance Sheet

(To be completed by ward/unit staff each day)

Daily Surveillance Tool for ARI and Enteric Infections in Acute Care Patient Units

Date: _____ Patient Unit: _____ Page ____ of _____

- **Each shift is to update this form.**
- **Any <u>new</u> onset of symptoms of fever, cough, and shortness of breath, vomiting, diarrhea and/or pneumonia in patients must be reported to the attending physician <u>immediately</u> and a message for Infection Prevention & Control must be left.**

Name/ HFN/ Room	Admission Date	Date of new Onset	Fever >38 °C	Cough	SOB	Hypoxia (O^2 Sat <92%)	Vomiting	Diarrhea	Droplet precautions (Yes or No)	ACTION (s)	Initials

[Adapted from Sunnybrook Health Sciences Centre, Toronto, Ontario]

Appendix F: Summary Sheet for Calculation of Infection Surveillance Rates

1. Incidence Density Rates (adjusts for patient/resident length of stay)

Example infections:

- AROs (infections and/or colonizations)
- Respiratory infections
- Skin and soft tissue infections

Number of cases over specified time period (e.g. surveillance quarter)___ x 10,000
Total number of days patients(residents)in hospital (facility) over time period

2. Device-Associated Infection Rates

Example infections

- Central line-associated bloodstream infections
- Ventilator-associated pneumonias
- Indwelling catheter-associated urinary tract infections

Number of cases over specified time period (e.g. surveillance quarter) x 1000
Total number of days that patients (residents) were exposed to the device

3. Surgical Site Infection Rates (SSIs)

Number of cases over specified time period following specific operative procedure x 100
Total number of days that patients underwent the same operative procedure
in the same time period

Stratification of SSI rates by wound class

For Wound Classes I-II only:

Number of cases over specified time period following specific operative procedure x 100
Total number of days that patients underwent the same operative procedure
in the same time period

For Wound Classes III-IV only:

Number of cases over specified time period following specific operative procedure x 100
Total number of days that patients underwent the same operative procedure
in the same time period

Appendix G: Operative Procedure Categories and Corresponding ICD-9-CM Procedural Codes

NHSN Operative Procedure Categories – FY 2010 Update				
Legacy Code	**New Code**	**Operative Procedure**	**Description**	**ICD-9-CM Codes**
AAA	2105-5	Abdominal aortic aneurysm repair	Resection of abdominal aorta with anastomosis or replacement	38.34, 38.44, 38.64
AMP	2126-1	Limb amputation	Total or partial amputation or disarticulation of the upper or lower limbs, including digits	84.00-84.19, 84.91
APPY	2108-9	Appendix surgery	Operation of appendix (not incidental to another procedure)	47.01, 47.09, 47.2, 47.91, 47.92, 47.99
AVSD	2102-2	Shunt for dialysis	Arteriovenostomy for renal dialysis	39.27, 39.42
BILI	2109-7	Bile duct, liver or pancreatic surgery	Excision of bile ducts or operative procedures on the biliary tract, liver or pancreas (does not include operations only on gallbladder)	50.0, 50.12, 50.14, 50.21-50.23, 50.25, 50.26, 50.29, 50.3, 50.4, 50.61, 50.69, 51.31-51.37, 51.39, 51.41-51.43, 51.49, 51.51, 51.59, 51.61-51.63, 51.69, 51.71, 51.72, 51.79, 51.81-51.83, 51.89, 51.91¬51.95, 51.99, 52.09, 52.12, 52.22, 52.3, 52.4, 52.51-52.53, 52.59¬52.6, 52.7, 52.92, 52.95, 52.96, 52.99
BRST	2110-5	Breast surgery	Excision of lesion or tissue of breast including radical, modified, or quadrant resection, lumpectomy, incisional biopsy, or mammoplasty.	85.12, 85.20-85.23, 85.31-85.36, 85.41-85.48, 85.50, 85.53, 85.54, 85.6, 85.70-85.76, 85.79, 85.93¬85.96

NHSN Operative Procedure Categories – FY 2010 Update				
Legacy Code	**New Code**	**Operative Procedure**	**Description**	**ICD-9-CM Codes**
CARD	2111-3	Cardiac surgery	Procedures on the valves or septum of heart; does not include coronary artery bypass graft, surgery on vessels, heart transplantation, or pacemaker implantation	35.00, 35.01, 35.02, 35.03, 35.04, 35.10-35.14, 35.20-35.28, 35.3135.35, 35.39, 35.42, 35.50, 35.51, 35.53, 35.54, 35.60-35.63, 35.7035.73, 35.81-35.84, 35.91-35.95, 35.98-35.99, 37.10, 37.11, 37.24, 37.31-37.33, 37.35, 37.36, 37.41, 37.49, 37.60*
CEA	2112-1	Carotid endarterectomy	Endarterectomy on vessels of head and neck (includes carotid artery and jugular vein)	38.12
CBGB	2113-9	Coronary artery bypass graft with **both** chest and donor site incisions	Chest procedure to perform direct revascularization of the heart; includes obtaining suitable vein from donor site for grafting.	36.10-36.14, 36.19
CBGC	2114-7	Coronary artery bypass graft with chest incision only	Chest procedure to perform direct vascularization of the heart using, for example the internal mammary (thoracid) artery	36.15-36.17, 36.2
CHOL	2119-6	Gallbladder surgery	Cholecystectomy and cholecystotomy	51.03, 51.04, 51.13, 51.21-51.24
COLO	2116-2	Colon surgery	Incision, resection, or anastomosis of the large intestine; includes large-to-small and small-to-large bowel anastomosis; does not include rectal operations	17.31-17.36, 17.39, 45.03, 45.26, 45.41, 45.49, 45.52, 45.71-45.76, 45.79, 45.81-45.83, 45.92-45.95, 46.03, 46.04, 46.10, 46.11, 46.13, 46.14, 46.43, 46.52, 46.75, 46.76, 46.94
CRAN	2117-0	Craniotomy	Incision through the skull to excise, repair, or explore the brain; does not include taps or punctures	01.12, 01.14, 01.21-01.25, 01.28, 01.31, 01.32, 01.39, 01.41, 01.42, 01.51-01.53, 01.59, 02.11-02.14, 02.91-02.93, 07.51-07.54, 07.59, 07.61-07.65, 07.68, 07.69, 07.71, 07.72, 07.79, 38.01, 38.11, 38.31, 38.41, 38.51, 38.61, 38.81, 39.28
CSEC	2115-4	Caesarean section	Obstetrical delivery by Caesarean section	74.0, 74.1, 74.2, 74.4, 74.91, 74.99
FUSN	2137-8	Spinal fusion	Immobilization of spinal column	81.00-81.08

NHSN Operative Procedure Categories – FY 2010 Update				
Legacy Code	**New Code**	**Operative Procedure**	**Description**	**ICD-9-CM Codes**
FX	2129-5	Open reduction of fracture	Open reduction of fracture or dislocation of long bones that requires internal or external fixation; does not include placement of joint prosthesis	79.21, 79.22, 79.25, 79.26, 79.31, 79.32, 79.35, 79.36, 79.51, 79.52, 79.55, 79.56
GAST	2120-4	Gastric surgery	Incision or excision of stomach; includes subtotal or total gastrectomy; does not include vagotomy and fundoplication	43.0, 43.42, 43.49, 43.5, 43.6, 43.7, 43.81, 43.89, 43.91, 43.99, 44.15, 44.21, 44.29, 44.31, 44.3844.42, 44.49, 44.5, 44.61-44.65, 44.68-44.69, 44.95-44.98
HER	2106-3	Herniorraphy	Repair of inguinal, femoral, umbilical, or anterior abdominal wall hernia; does not include repair of diaphragmatic or hiatal hernia or hernias at other body sites.	17.11-17.13, 17.21-17.24, 53.0053.05, 53.10-53.17, 53.21, 53.29, 53.31, 53.39, 53.41-53.43, 53.49, 53.51, 53.59, 53.61-53.63, 53.69
HPRO	2101-4	Hip prosthesis	Arthroplasty of hip	00.70-00.73, 00.85-00.87, 81.5181.53
HTP	2121-2	Heart transplant	Transplantation of heart	37.51-37.55
HYST	2107-1	Abdominal hysterectomy	Removal of uterus through an abdominal incision	68.31, 68.39, 68.41, 68.49, 68.61, 68.69
KPRO	2124-6	Knee prosthesis	Arthroplasty of knee	00.80-00.84, 81.54, 81.55
KTP	2123-8	Kidney transplant	Transplantation of kidney	55.61, 55.69
LAM	2125-3	Laminectomy	Exploration or decompression of spinal cord through excision or incision into vertebral structures	03.01, 03.02, 03.09, 80.50, 80.51, 80.53, 80.54**+,** 80.59, 84.60-84.69, 84.80-84.85
LTP	2127-9	Liver transplant	Transplantation of liver	50.51, 50.59
NECK	2128-7	Neck surgery	Major excision or incision of the larynx and radical neck dissection; does not include thyroid and parathyroid operations.	30.1, 30.21, 30.22, 30.29, 30.3, 30.4, 31.45, 40.40-40.42

NHSN Operative Procedure Categories – FY 2010 Update				
Legacy Code	**New Code**	**Operative Procedure**	**Description**	**ICD-9-CM Codes**
NEPH	2122-0	Kidney surgery	Resection or manipulation of the kidney with or without removal of related structures	55.01-55.02, 55.11, 55.12, 55.24, 55.31, 55.32, 55.34, 55.35, 55.39, 55.4, 55.51, 55.52, 55.54, 55.91
OVRY	2130-3	Ovarian surgery	Operations on ovary and related structures	65.01, 65.09, 65.12, 65.13, 65.2165.25, 65.29, 65.31, 65.39, 65.41, 65.49, 65.51-65.54, 65.61-65.64, 65.71-65.76, 65.79, 65.81, 65.89, 65.92-65.95, 65.99
PACE	2131-1	Pacemaker surgery	Insertion, manipulation or replacement of pacemaker	00.50-00.54, 17.51, 17.52, 37.7037.77, 37.79-37.83, 37.85-37.87, 37.89, 37.94-37.99
PRST	2133-7	Prostate surgery	Suprapubic, retropubic, radical, or perineal excision of the prostate; does not include transurethral resection of the prostate.	60.12, 60.3, 60.4, 60.5, 60.61, 60.62, 60.69
PVBY	2132-9	Peripheral vascular bypass surgery	Bypass operations on peripheral arteries	39.29
REC	2134-5	Rectal surgery	Operations on rectum	48.25, 48.35, 48.40, 48.42, 48.43, 48.49-48.52, 48.59, 48.61-48.65, 48.69, 48.74
RFUSN	2135-2	Refusion of spine	Refusion of spine	81.30-81.39
SB	2136-0	Small bowel surgery	Incision or resection of the small intestine; does not include small-to-large bowel anastomosis	45.01, 45.02, 45.15, 45.31-45.34, 45.51, 45.61-45.63, 45.91, 46.01, 46.02, 46.20-46.24, 46.31, 46.39, 46.41, 46.51, 46.71-46.74, 46.93
SPLE	2138-6	Spleen surgery	Resection or manipulation of spleen	41.2, 41.33, 41.41-41.43, 41.5, 41.93, 41.95, 41.99

NHSN Operative Procedure Categories – FY 2010 Update				
Legacy Code	**New Code**	**Operative Procedure**	**Description**	**ICD-9-CM Codes**
THOR	2139-4	Thoracic surgery	Noncardiac, nonvascular thoracic surgery; includes pneumonectomy and diaphragmatic or hiatal hernia repair	32.09, 32.1, 32.20, 32.21-32.23, 32.25, 32.26, 32.29, 32.30, 32.39, 32.41, 32.49, 32.50, 32.59, 32.6, 32.9, 33.0, 33.1, 33.20, 33.25, 33.28, 33.31-33.34, 33.39, 33.4133.43, 33.48, 33.49, 33.98, 33.99, 34.01-34.03, 34.06, 34.1, 34.20, 34.26, 34.3, 34.4, 34.51, 34.52, 34.59, 34.6, 34.81-34.84, 34.89, 34.93, 34.99, 53.71, 53.72, 53.75, 53.80-53.84
THYR	2140-2	Thyroid and/or parathyroid surgery	Resection or manipulation of thyroid and/or parathyroid	06.02, 06.09, 06.12, 06.2, 06.31, 06.39, 06.4, 06.50-06.52, 06.6, 06.7, 06.81, 06.89, 06.91-06.95, 06.98, 06.99
VHYS	2141-0	Vaginal hysterectomy	Removal of the uterus through vaginal or perineal incision	68.51, 68.59, 68.71, 68.79
VSHN	2142-8	Ventricular shunt	Ventricular shunt operations, including revision and removal of shunt	02.2, 02.31-02.35, 02.39, 02.42, 02.43, 54.95
XLAP	2118-8	Abdominal surgery	Abdominal operations not involving the gastrointestinal tract or biliary system	53.71-53.72, 53.75, 54.0, 54.11, 54.12, 54.19, 54.3, 54.4, 54.51, 54.59, 54.61, 54.63, 54.64

[Source: National Healthcare Safety Network. NHSN Operative Procedure Categories – FY 2010 Update. Atlanta, GA: Centers for Disease Control and Prevention; 2010 Jun. Available from: http://www.cdc.gov/nhsn/PDFs/OperativeProcedures.pdf]

Appendix H: Classification of Surgical Procedures According to Wound Class Risk

Wound class	Definition	Examples	Risk of Surgical Site Infection
Dirty surgery (IV)	▪ Clinically infected operative wound or perforated viscera or old, traumatic wound with retained devitalized tissue, purulent draining	▪ Repair of an open fracture that occurred three days earlier	HIGH RISK
Contaminated surgery (III)	▪ Acute, nonpurulent, inflamed operative wound or open fresh, accidental wound ▪ An operative procedure with major breaks in sterile technique or gross spillage; macroscopic soiling of the operative field	▪ Appendectomy for appendicitis ▪ Biliary or genitourinary tract surgery with infected bile or urine	
Clean-contaminated surgery (II)	▪ Uninfected operative wound where the respiratory, alimentary, genital, or uninfected urinary tracts are entered	▪ Laryngectomy ▪ Elective colorectal surgery ▪ Uncomplicated appendectomy ▪ Cholecystectomy ▪ Transurethral resection of prostate gland	
Clean surgery (I)	▪ Uninfected, uninflamed operative wound where mucosa of the respiratory, alimentary, genitourinary tract or oropharyngeal cavity are not transversed (i.e., involves only sterile body sites) ▪ Insertion of prosthesis or artificial device	▪ Herniorraphy ▪ Mastectomy ▪ Cosmetic surgery ▪ Knee/hip replacement, heart valve	LOW RISK

[Adapted from: Roy MC, Infect Control Hosp Epidemiol, 2000[155]; Friedman ND, Infect Control Hosp Epidemiol 2006[154]]

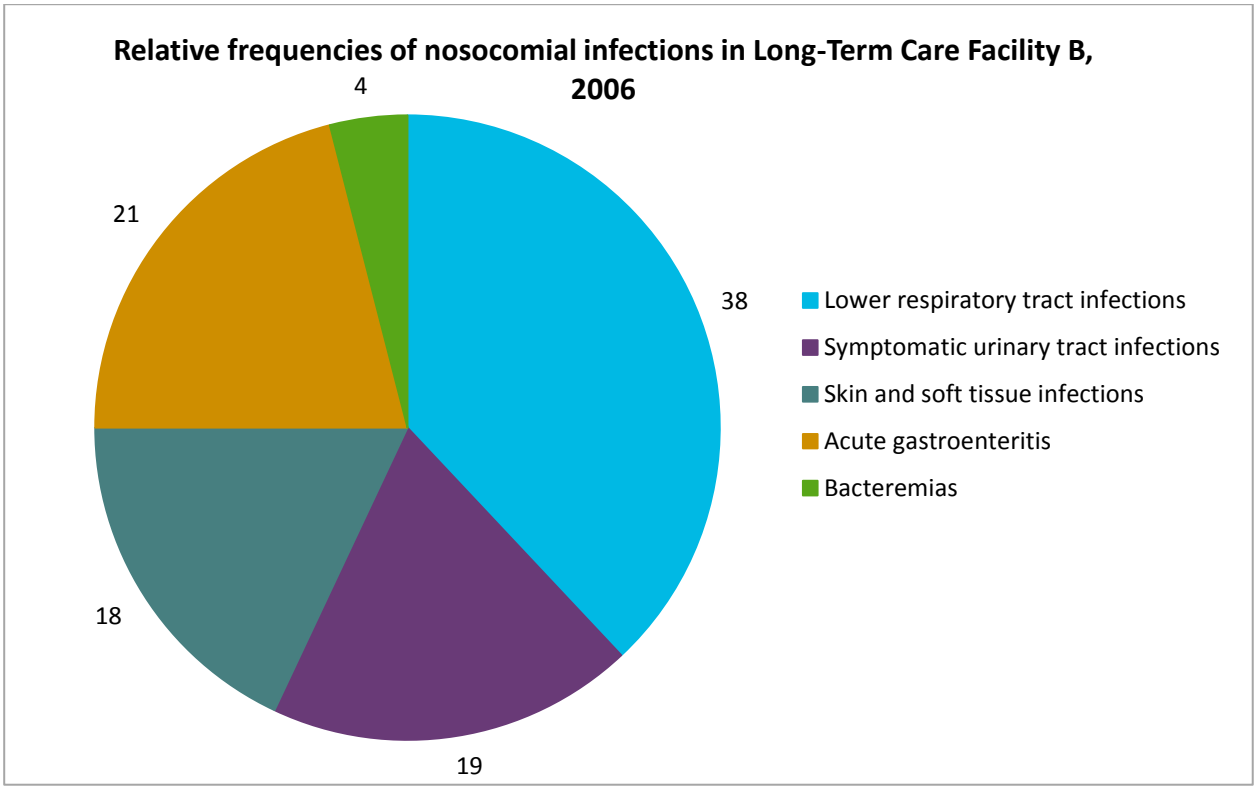
Appendix I: Tools for the Display of Surveillance Data

General guidelines for the presentation of data in graph or chart form are as follows:

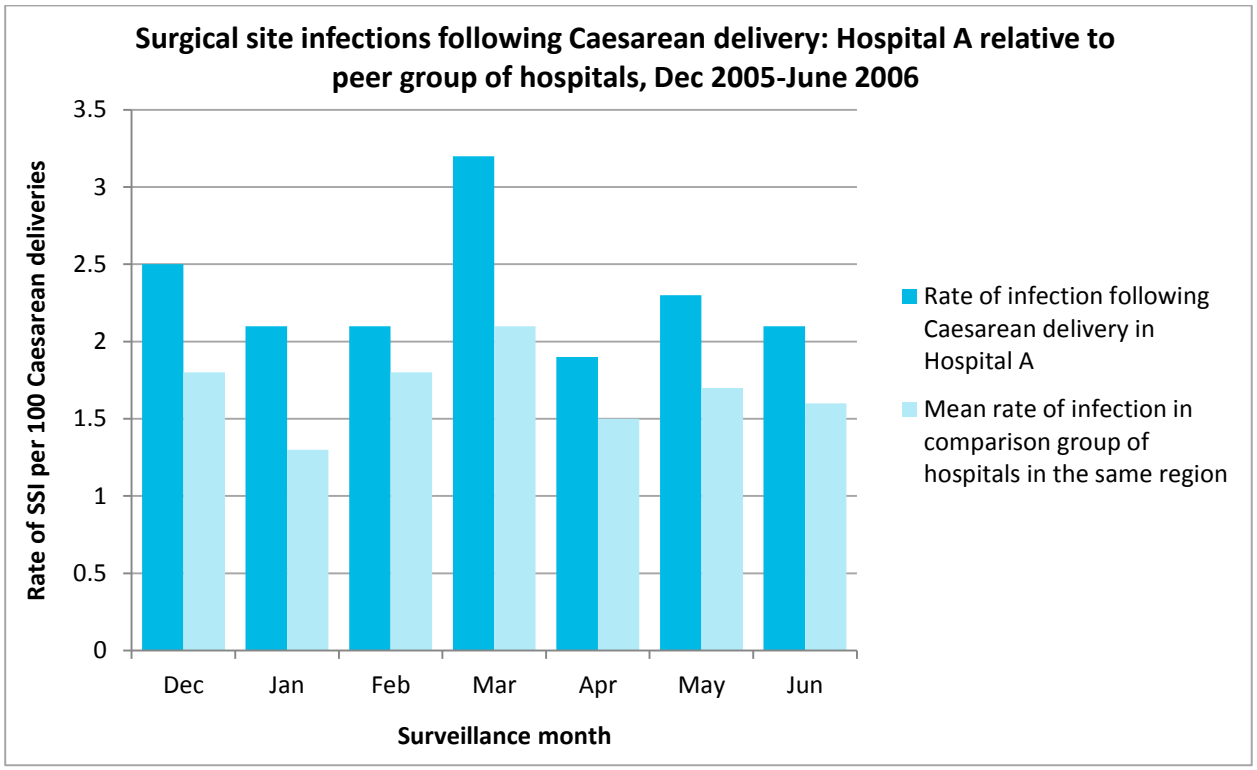
1. There should be a title (and sub-title, if necessary) that clearly outlines the data being presented.
2. For graphs and bar charts, the rate of infection is usually presented on the Y (or vertical) axis and the units of the scale should be consistent (i.e., units should not change half-way up the axis).
3. The denominator should be clearly indicated (e.g., per 1,000 resident days, per 1,000 central line days).
4. Time is usually presented on the X (or horizontal) axis.
5. Graphs and charts should include a legend.
6. The use of colour often adds to a graph but coloured graphs should not lose their meaning when printed in black and white (e.g., for those printing surveillance reports on a black and white office printer).
7. The timeframe for the surveillance period should be clearly indicated on the graph (e.g., Surveillance Q1 (Jan-March 2006), Influenza season (Nov-Apr. 2007).
8. In some cases it may be useful to have a data table below the graph so that the reader can check the exact value.

The figures below provide examples of the visual display of surveillance data. Additional examples are provided in the document, Boxes 18 and 19.

Pie chart of data on HAI in a long-term care home:



Bar graph displaying rates of procedure-specific surgical site infections with accompanying data table:



	Dec	Jan	Feb	Mar	Apr	May	Jun
Rate of infection following Caesarean delivery in Hospital A per 100 Caesarean deliveries	2.5	2.1	2.1	3.2	1.9	2.3	2.1
Mean rate of infection in comparison group of hospitals in the same region per 100 Caesarean deliveries	1.8	1.3	1.8	2.1	1.5	1.7	1.6

Appendix J: Surgical Care Improvement Project (SCIP) Procedures, NHSN Procedure Categories Approximating SCIP Procedures, and Validated Parameters for Surgical Site Infection Risk Models in NHSN

SCIP Procedure	NHSN Procedure Category	Validated Parameters for Risk Model
Vascular	Abdominal arotic aneurysm repair	duration of procedure, wound class
	Peripheral vascular bypass surgery	age, ASA, duration of procedure, medical school affiliation
Coronary artery bypass graft	Coronary artery bypass graft with both chest and donor site incisions;Coronary artery bypass graft with chest incision only	age, ASA, duration of procedure, gender, medical school affiliation, age gender (interaction)
Other cardiac	Cardiac surgery	age, duration of procedure, emergency
Colon surgery	Colon surgery	age, ASA, duration, endoscope, medical school affiliation, hospital bed size, wound class
	Rectal surgery	duration of procedure, gender, hospital bed size
Hip Arthroplasty	Hip arthroplasty (both primary and revision hip arthroplasties)	total/partial/revision, age, anesthesia, ASA, duration of procedure, medical school affiliation, hospital bed size, trauma
Abdominal hysterectomy	Abdominal hysterectomy	age, ASA, duration of procedure, hospital bed size
Vaginal hysterectomy	Vaginal hysterectomy	age, duration of procedure, medical school affiliation
Knee Arthroplasty	Knee arthroplasty	age, ASA, duration of procedure, gender, medical school affiliation, hospital bed size, trauma, revision

Reprinted with permission from Centres for Disease Control. 2011 National and State Healthcare-Associated Infections Standardized Infection Ratio Report, January-December 2011; Appendix A, *Surgical Care Improvement Project (SCIP) Procedures, NHSN Procedure Categories Approximating SCIP Procedures, and Validated Parameters for Surgical Site Infection Risk Models in NHSN*.[151]

Appendix K: Search Strategy

Search Strategies Used in this Revision of "*Surveillance of health care-associated infections in patient and resident populations*":

Literature searches were conducted in MEDLINE (Ovid) and the Cochrane Database of Systematic Reviews, with additional searches conducted via the Ovid platform in EMBASE and BIOSIS Previews for selected topics from 1945 to July 2013, primarily focusing on the years 2011 to the present. Only English and Dutch language articles that were peer-reviewed original articles or systematic reviews were retrieved (i.e., Canada, United States, Australia, European Union). Also included was strong grey literature, e.g., government publications that were not peer-reviewed. Articles that only provided a summary were excluded.

The search concepts were expressed in combination of database specific controlled vocabularies (MeSH, Emtree, CINAHL SH) and keywords. Boolean logic was applied as was proximity searching.

The initial scoping literature search on surveillance for health care-associated infections was conducted in July 2013. The strategies were designed to retrieve information on the following topics:

1. Cost of healthcare-associated infections
2. Surveillance of healthcare-associated infections
3. Healthcare-associated infection surveillance methods
4. Morbidity and mortality of healthcare-associated infections

Bibliographic Databases: Search Strategies

COST OF HEALTHCARE-ASSOCIATED INFECTIONS

Database: Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations and Ovid MEDLINE(R) 1946 to Present		
#	**Searches**	**Results**
1	exp Models, Economic/ or Economics/ or exp "Costs and Cost Analysis"/ or Cost-Benefit Analysis/ or Cost of Illness/ or exp Health Care Costs/ or Health Expenditures/ or exp "Economics, Hospital"/ or "Economics, Medical"/ or "Economics, Nursing"/ or "Economics, Behavioral"/ or economics.fs.	416440
2	(cost$ or economic$ or expenditure$ or burden or (value adj2 money) or (value adj2 dollar$)).ti.	129001
3	(cost$ or economic$ or expenditure$ or burden or (value adj2 money) or (value adj2 dollar$)).ab. /freq=3	94750
4	2 or 3	170535
5	limit 4 to ("in data review" or in process or "pubmed not medline")	10904
6	1 or 5	427344
7	clostridium difficile/ or methicillin-resistant staphylococcus aureus/ or vancomycin resistance/ or (exp enterococcus/ and vancomycin/) or (carbapenems/ and (enterobacteriaceae/ or enterobacteriaceae infections/)) or surgical wound infection/ or catheterization, central venous/ or catheter-related infections/ or catheters, indwelling/ae or catheters, indwelling/mi or pneumonia, ventilator-associated/ or exp ventilators, mechanical/mi or exp ventilators, mechanical/ae or urinary catheterization/ae or urinary tract infections/ or cross infection/	131111
8	(clostridium difficile* or "c. diff" or "c. difficile" or CDI or CDAD or methicillin-resistant staphylococcus aureus or MRSA or vancomycin-resistant enterococc* or VRE or carbapenemase-producing enterobacteriaceae or CPE or surgical site infection* or surgical wound infection* or SSI or SSIs or ventilator-associated pneumonia or VAP or ventilator-associated event* or VAE or (central line* adj3 infection*) or (catheter* adj3 infection*) or CLABSI or	37937

Database: Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations and Ovid MEDLINE(R) 1946 to Present		
#	**Searches**	**Results**
	(urinary tract infection* adj3 catheter*) or CAUTI or CAUTIs or UTI or UTIs or antimicrobial resist* or microbial resist* or ARO or AROs or nosocomial or healthcare-acquired or healthcare-associated or health care-acquired or health care-associated or hospital-acquired or hospital-associated or HAI or HAIs).ti.	
9	(clostridium difficile* or "c. diff" or "c. difficile" or CDI or CDAD or methicillin-resistant staphylococcus aureus or MRSA or vancomycin-resistant enterococc* or VRE or carbapenemase-producing enterobacteriaceae or CPE or surgical site infection* or surgical wound infection* or SSI or SSIs or ventilator-associated pneumonia or VAP or ventilator-associated event* or VAE or (central line* adj3 infection*) or (catheter* adj3 infection*) or CLABSI or (urinary tract infection* adj3 catheter*) or CAUTI or CAUTIs or UTI or UTIs or antimicrobial resist* or microbial resist* or ARO or AROs or nosocomial or healthcare-acquired or healthcare-associated or health care-acquired or health care-associated or hospital-acquired or hospital-associated or HAI or HAIs).ab. /freq=3	31483
10	8 or 9	51891
11	limit 10 to ("in data review" or in process or "pubmed not medline")	3180
12	7 or 11	134291
13	6 and 12	3799
14	limit 13 to yr="2011 -Current"	554

Database: Embase 1996 to 2013 Week 28		
#	**Searches**	**Results**
1	economic aspect/ or exp "cost"/ or exp economics/ or exp health economics/ or cost benefit analysis/ or behavioral economics/ or cost effectiveness analysis/ or cost minimization analysis/ or "cost of illness"/ or cost utility analysis/ or economic evaluation/ or "health care cost"/ or "hospital cost"/ or "hospitalization cost"/	549863
2	(cost$ or economic$ or expenditure$ or burden or (value adj2 money) or (value adj2 dollar$)).ti,sh.	363177
3	(cost$ or economic$ or expenditure$ or burden or (value adj2 money) or (value adj2 dollar$)).ab. /freq=3	101081
4	1 or 2 or 3	602130
5	clostridium difficile/ or cross infection/ or clostridium difficile infection/ or methicillin resistant staphylococcus aureus/ or vancomycin resistant staphylococcus aureus/ or vancomycin resistant enterococcus/ or vancomycin intermediate staphylococcus aureus/ or vancomycin susceptible staphylococcus aureus/ or (carbapenemase/ and (enterobacteriaceae infection/ or enterobacteriaceae/)) or surgical infection/ or urinary tract infection/ or catheter infection/ or hospital infection/ or ventilator associated pneumonia/ or ((ventilated patient/ or ventilator/) and infection/) or antibiotic resistance/ or cross infection/ or exp ventilator/ or central venous catheterization/ or (urinary tract infection/ and catheter/) or (urinary catheter/ and infection/)	195707
6	(clostridium difficile* or "c. diff" or "c. difficile" or CDI or CDAD or methicillin-resistant staphylococcus aureus or MRSA or vancomycin-resistant enterococc* or VRE or carbapenemase-producing enterobacteriaceae or CPE or surgical site infection* or surgical wound infection* or SSI or SSIs or ventilator-associated pneumonia or VAP or ventilator-associated event* or VAE or (central line* adj3 infection*) or (catheter* adj3 infection*) or CLABSI or (urinary tract infection* adj3 catheter*) or CAUTI or CAUTIs or UTI or UTIs or antimicrobial resist* or microbial resist* or ARO or AROs or nosocomial or healthcare-acquired or healthcare-associated or health care-acquired or health care-associated or hospital-acquired or hospital-associated or HAI or HAIs).ti,sh.	65605
7	(clostridium difficile* or "c. diff" or "c. difficile" or CDI or CDAD or methicillin-resistant staphylococcus aureus or MRSA or vancomycin-resistant enterococc* or VRE or carbapenemase-producing enterobacteriaceae or CPE or surgical site infection* or surgical wound infection* or SSI or SSIs or ventilator-associated pneumonia or VAP or ventilator-associated event* or VAE or (central line* adj3 infection*) or (catheter* adj3 infection*) or CLABSI or (urinary tract infection* adj3 catheter*) or CAUTI or CAUTIs or UTI or UTIs or antimicrobial resist* or microbial	35302

Database: Embase 1996 to 2013 Week 28		
#	**Searches**	**Results**
	resist* or ARO or AROs or nosocomial or healthcare-acquired or healthcare-associated or health care-acquired or health care-associated or hospital-acquired or hospital-associated or HAI or HAIs).ab. /freq=3	
8	5 or 6 or 7	207335
9	exp health care facility/ or cross infection/ or healthcare associated infection/ or hospital infection/	639652
10	(hospital* or long-term care* or ((health* or medical or care or nursing or tertiary or mental health or rehab*) adj3 (facility or facilities or centre or center or setting* or home))).ti,sh.	718503
11	(hospital* or long-term care* or ((health* or medical or care or nursing or tertiary or mental health or rehab*) adj3 (facility or facilities or centre or center or setting* or home))).ab. /freq=3	158813
12	9 or 10 or 11	1071849
13	4 and 8 and 12	7514
14	limit 13 to exclude medline journals	837
15	limit 14 to yr="2011 -Current"	207

Database: Cochrane Database of Systematic Reviews		
#	**Searches**	**Results**
1	TI (clostridium difficile* or "c. diff" or "c. difficile" or CDI or CDAD or methicillin-resistant staphylococcus aureus or MRSA or vancomycin-resistant enterococc* or VRE or carbapenemase-producing enterobacteriaceae or CPE or surgical site infection* or surgical wound infection* or SSI or SSIs or ventilator-associated pneumonia or VAP or ventilator-associated event* or VAE or (central line* N3 infection*) or (catheter* N3 infection*) or CLABSI or (urinary tract infection* N3 catheter*) or CAUTI or CAUTIs or UTI or UTIs or antimicrobial resist* or microbial resist* or ARO or AROs or nosocomial or healthcare-acquired or healthcare-associated or health care-acquired or health care-associated or hospital-acquired or hospital-associated or HAI or HAIs) OR AB (clostridium difficile* or "c. diff" or "c. difficile" or CDI or CDAD or methicillin-resistant staphylococcus aureus or MRSA or vancomycin-resistant enterococc* or VRE or carbapenemase-producing enterobacteriaceae or CPE or surgical site infection* or surgical wound infection* or SSI or SSIs or ventilator-associated pneumonia or VAP or ventilator-associated event* or VAE or (central line* N3 infection*) or (catheter* N3 infection*) or CLABSI or (urinary tract infection* N3 catheter*) or CAUTI or CAUTIs or UTI or UTIs or antimicrobial resist* or microbial resist* or ARO or AROs or nosocomial or healthcare-acquired or healthcare-associated or health care-acquired or health care-associated or hospital-acquired or hospital-associated or HAI or HAIs) OR SU (clostridium difficile* or "c. diff" or "c. difficile" or CDI or CDAD or methicillin-resistant staphylococcus aureus or MRSA or vancomycin-resistant enterococc* or VRE or carbapenemase-producing enterobacteriaceae or CPE or surgical site infection* or surgical wound infection* or SSI or SSIs or ventilator-associated pneumonia or VAP or ventilator-associated event* or VAE or (central line* N3 infection*) or (catheter* N3 infection*) or CLABSI or (urinary tract infection* N3 catheter*) or CAUTI or CAUTIs or UTI or UTIs or antimicrobial resist* or microbial resist* or ARO or AROs or nosocomial or healthcare-acquired or healthcare-associated or health care-acquired or health care-associated or hospital-acquired or hospital-associated or HAI or HAIs)	174
2	TI (cost* or economic* or expenditure* or burden or (value N2 money) or (value N2 dollar*)) OR AB (cost* or economic* or expenditure* or burden or (value N2 money) or (value N2 dollar*)) OR SU (cost* or economic* or expenditure* or burden or (value N2 money) or (value N2 dollar*))	1,057
3	S1 AND S2 Limiters - Date of Last Edited Version/Most Recent Substantive Amendment from: 20110101-20131231	25

Database: EconLit		
#	**Searches**	**Results**
1	ti(clostridium difficile* OR c difficile OR c diff OR methicillin-resistant staphylococcus aureus OR vancomycin-resistant enterococc* OR carbapenemase-producing enterobacteriaceae OR surgical site infection* OR surgical wound infection* OR ventilator-associated pneumonia OR VAP OR ventilator-associated event* OR (central line* N/3 infection*) OR (catheter* N/3 infection*) OR urinary tract infection OR antimicrobial resist* OR microbial resist* OR nosocomial OR healthcare-acquired OR healthcare-associated OR health care-acquired OR health care-associated OR hospital-acquired OR hospital-associated) OR ab(clostridium difficile* OR c difficile OR c diff OR methicillin-resistant staphylococcus aureus OR vancomycin-resistant enterococc* OR carbapenemase-producing enterobacteriaceae OR surgical site infection* OR surgical wound infection* OR ventilator-associated pneumonia OR VAP OR ventilator-associated event* OR (central line* N/3 infection*) OR (catheter* N/3 infection*) OR urinary tract infection OR antimicrobial resist* OR microbial resist* OR nosocomial OR healthcare-acquired OR healthcare-associated OR health care-acquired OR health care-associated OR hospital-acquired OR hospital-associated) Narrowed by: Year: 2011; 2012; 2013	145

Database: Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations and Ovid MEDLINE(R) 1946 to Present		
#	**Searches**	**Results**
1	public health surveillance/ or population surveillance/ or biosurveillance/ or sentinel surveillance/ or public health informatics/ or data collection/mt	62320
2	(surveillance or monitor* or detect* or track* or threshold* or baseline* or endemic* or benchmark* or case finding or (public adj3 report*) or early warning or syndromic* or data mining or (data adj3 collect*) or sentinel event*).ti.	426663
3	(surveillance or monitor* or detect* or track* or threshold* or baseline* or endemic* or benchmark* or case finding or (public adj3 report*) or early warning or syndromic* or data mining or (data adj3 collect*) or sentinel event*).ab. /freq=3	384344
4	2 or 3	687036
5	limit 4 to ("in data review" or in process or "pubmed not medline")	48146
6	1 or 5	110466
7	clostridium difficile/ or methicillin-resistant staphylococcus aureus/ or vancomycin resistance/ or (exp enterococcus/ and vancomycin/) or (carbapenems/ and (enterobacteriaceae/ or enterobacteriaceae infections/)) or surgical wound infection/ or catheterization, central venous/ or catheter-related infections/ or catheters, indwelling/ae or catheters, indwelling/mi or pneumonia, ventilator-associated/ or exp ventilators, mechanical/mi or exp ventilators, mechanical/ae or urinary catheterization/ae or urinary tract infections/ or cross infection/	131111
8	(clostridium difficile* or "c. diff" or "c. difficile" or CDI or CDAD or methicillin-resistant staphylococcus aureus or MRSA or vancomycin-resistant enterococc* or VRE or carbapenemase-producing enterobacteriaceae or CPE or surgical site infection* or surgical wound infection* or SSI or SSIs or ventilator-associated pneumonia or VAP or ventilator-associated event* or VAE or (central line* adj3 infection*) or (catheter* adj3 infection*) or CLABSI or (urinary tract infection* adj3 catheter*) or CAUTI or CAUTIs or UTI or UTIs or antimicrobial resist* or microbial resist* or ARO or AROs or nosocomial or healthcare-acquired or healthcare-associated or health care-acquired or health care-associated or hospital-acquired or hospital-associated or HAI or HAIs).ti.	37937
9	(clostridium difficile* or "c. diff" or "c. difficile" or CDI or CDAD or methicillin-resistant staphylococcus aureus or MRSA or vancomycin-resistant enterococc* or VRE or carbapenemase-producing enterobacteriaceae or CPE or surgical site infection* or surgical wound infection* or SSI or SSIs or ventilator-associated pneumonia or VAP or ventilator-associated event* or VAE or (central line* adj3 infection*) or (catheter* adj3 infection*) or CLABSI or (urinary tract infection* adj3 catheter*) or CAUTI or CAUTIs or UTI or UTIs or antimicrobial resist* or microbial resist* or ARO or AROs or nosocomial or healthcare-acquired or healthcare-associated or health care-acquired or health care-associated or hospital-acquired or hospital-associated or HAI or HAIs).ab. /freq=3	31483
10	8 or 9	51891
11	limit 10 to ("in data review" or in process or "pubmed not medline")	3180
12	7 or 11	134291
13	exp health facilities/ or cross infection/	619613
14	(hospital* or long-term care* or ((health* or medical or care or nursing or tertiary or mental health or rehab*) adj3 (facility or facilities or centre or center or setting* or home))).ti.	274529
15	(hospital* or long-term care* or ((health* or medical or care or nursing or tertiary or mental health or rehab*) adj3 (facility or facilities or centre or center or setting* or home))).ab. /freq=3	144084
16	13 or 14 or 15	802877
17	6 and 12 and 16	2222

Database: Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations and Ovid MEDLINE(R) 1946 to Present		
#	**Searches**	**Results**
18	limit 17 to yr="2011 -Current"	359

Database: Embase 1996 to 2013 Week 28		
#	**Searches**	**Results**
1	disease surveillance/ or sentinel surveillance/ or biosurveillance/ or medical informatics/	21848
2	(surveillance or monitor* or detect* or track* or threshold* or baseline* or endemic* or benchmark* or case finding or (public adj3 report*) or early warning or syndromic* or data mining or (data adj3 collect*) or sentinel event*).ti,sh.	386470
3	(surveillance or monitor* or detect* or track* or threshold* or baseline* or endemic* or benchmark* or case finding or (public adj3 report*) or early warning or syndromic* or data mining or (data adj3 collect*) or sentinel event*).ab. /freq=3	392368
4	1 or 2 or 3	664209
5	clostridium difficile/ or cross infection/ or clostridium difficile infection/ or methicillin resistant staphylococcus aureus/ or vancomycin resistant staphylococcus aureus/ or vancomycin resistant enterococcus/ or vancomycin intermediate staphylococcus aureus/ or vancomycin susceptible staphylococcus aureus/ or (carbapenemase/ and (enterobacteriaceae infection/ or enterobacteriaceae/)) or surgical infection/ or urinary tract infection/ or catheter infection/ or hospital infection/ or ventilator associated pneumonia/ or ((ventilated patient/ or ventilator/) and infection/) or antibiotic resistance/ or cross infection/ or exp ventilator/ or central venous catheterization/ or (urinary tract infection/ and catheter/) or (urinary catheter/ and infection/)	195707
6	(clostridium difficile* or "c. diff" or "c. difficile" or CDI or CDAD or methicillin-resistant staphylococcus aureus or MRSA or vancomycin-resistant enterococc* or VRE or carbapenemase-producing enterobacteriaceae or CPE or surgical site infection* or surgical wound infection* or SSI or SSIs or ventilator-associated pneumonia or VAP or ventilator-associated event* or VAE or (central line* adj3 infection*) or (catheter* adj3 infection*) or CLABSI or (urinary tract infection* adj3 catheter*) or CAUTI or CAUTIs or UTI or UTIs or antimicrobial resist* or microbial resist* or ARO or AROs or nosocomial or healthcare-acquired or healthcare-associated or health care-acquired or health care-associated or hospital-acquired or hospital-associated or HAI or HAIs).ti,sh.	65605
7	(clostridium difficile* or "c. diff" or "c. difficile" or CDI or CDAD or methicillin-resistant staphylococcus aureus or MRSA or vancomycin-resistant enterococc* or VRE or carbapenemase-producing enterobacteriaceae or CPE or surgical site infection* or surgical wound infection* or SSI or SSIs or ventilator-associated pneumonia or VAP or ventilator-associated event* or VAE or (central line* adj3 infection*) or (catheter* adj3 infection*) or CLABSI or (urinary tract infection* adj3 catheter*) or CAUTI or CAUTIs or UTI or UTIs or antimicrobial resist* or microbial resist* or ARO or AROs or nosocomial or healthcare-acquired or healthcare-associated or health care-acquired or health care-associated or hospital-acquired or hospital-associated or HAI or HAIs).ab. /freq=3	35302
8	5 or 6 or 7	207335
9	exp health care facility/ or cross infection/ or healthcare associated infection/ or hospital infection/	639652
10	(hospital* or long-term care* or ((health* or medical or care or nursing or tertiary or mental health or rehab*) adj3 (facility or facilities or centre or center or setting* or home))).ti,sh.	718503
11	(hospital* or long-term care* or ((health* or medical or care or nursing or tertiary or mental health or rehab*) adj3 (facility or facilities or centre or center or setting* or home))).ab. /freq=3	158813
12	9 or 10 or 11	1071849
13	4 and 8 and 12	7779

Database: Embase 1996 to 2013 Week 28		
#	**Searches**	**Results**
14	limit 13 to exclude medline journals	733
15	limit 14 to yr="2011 -Current"	321

Database: Cochrane Database of Systematic Reviews		
#	**Searches**	**Results**
S1	TI (surveillance or monitor* or detect* or track* or threshold* or baseline* or endemic* or benchmark* or case finding or (public N3 report*) or early warning or syndromic* or data mining or (data N3 collect*) or sentinel event*) OR AB (surveillance or monitor* or detect* or track* or threshold* or baseline* or endemic* or benchmark* or case finding or (public N3 report*) or early warning or syndromic* or data mining or (data N3 collect*) or sentinel event*) OR SU (surveillance or monitor* or detect* or track* or threshold* or baseline* or endemic* or benchmark* or case finding or (public N3 report*) or early warning or syndromic* or data mining or (data N3 collect*) or sentinel event*)	1,453
S2	TI (clostridium difficile* or "c. diff" or "c. difficile" or CDI or CDAD or methicillin-resistant staphylococcus aureus or MRSA or vancomycin-resistant enterococc* or VRE or carbapenemase-producing enterobacteriaceae or CPE or surgical site infection* or surgical wound infection* or SSI or SSIs or ventilator-associated pneumonia or VAP or ventilator-associated event* or VAE or (central line* N3 infection*) or (catheter* N3 infection*) or CLABSI or (urinary tract infection* N3 catheter*) or CAUTI or CAUTIs or UTI or UTIs or antimicrobial resist* or microbial resist* or ARO or AROs or nosocomial or healthcare-acquired or healthcare-associated or health care-acquired or health care-associated or hospital-acquired or hospital-associated or HAI or HAIs) OR AB (clostridium difficile* or "c. diff" or "c. difficile" or CDI or CDAD or methicillin-resistant staphylococcus aureus or MRSA or vancomycin-resistant enterococc* or VRE or carbapenemase-producing enterobacteriaceae or CPE or surgical site infection* or surgical wound infection* or SSI or SSIs or ventilator-associated pneumonia or VAP or ventilator-associated event* or VAE or (central line* N3 infection*) or (catheter* N3 infection*) or CLABSI or (urinary tract infection* N3 catheter*) or CAUTI or CAUTIs or UTI or UTIs or antimicrobial resist* or microbial resist* or ARO or AROs or nosocomial or healthcare-acquired or healthcare-associated or health care-acquired or health care-associated or hospital-acquired or hospital-associated or HAI or HAIs) OR SU (clostridium difficile* or "c. diff" or "c. difficile" or CDI or CDAD or methicillin-resistant staphylococcus aureus or MRSA or vancomycin-resistant enterococc* or VRE or carbapenemase-producing enterobacteriaceae or CPE or surgical site infection* or surgical wound infection* or SSI or SSIs or ventilator-associated pneumonia or VAP or ventilator-associated event* or VAE or (central line* N3 infection*) or (catheter* N3 infection*) or CLABSI or (urinary tract infection* N3 catheter*) or CAUTI or CAUTIs or UTI or UTIs or antimicrobial resist* or microbial resist* or ARO or AROs or nosocomial or healthcare-acquired or healthcare-associated or health care-acquired or health care-associated or hospital-acquired or hospital-associated or HAI or HAIs)	174
S3	S1 AND S2 Limiters - Date of Last Edited Version/Most Recent Substantive Amendment from: 20110101-20131231	21

HEALTHCARE-ASSOCIATED INFECTION SURVEILLANCE METHODS

Database: Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations and Ovid MEDLINE(R) 1946 to Present		
#	**Searches**	**Results**
1	clostridium difficile/ or methicillin-resistant staphylococcus aureus/ or vancomycin resistance/ or (exp enterococcus/ and vancomycin/) or (carbapenems/ and (enterobacteriaceae/ or enterobacteriaceae infections/)) or surgical wound infection/ or catheterization, central venous/ or catheter-related infections/ or catheters, indwelling/ae or catheters, indwelling/mi or pneumonia, ventilator-associated/ or exp ventilators, mechanical/mi or exp ventilators, mechanical/ae or urinary catheterization/ae or urinary tract infections/ or cross infection/	131402
2	(clostridium difficile* or "c. diff" or "c. difficile" or CDI or CDAD or methicillin-resistant staphylococcus aureus or MRSA or vancomycin-resistant enterococc* or VRE or carbapenemase-producing enterobacteriaceae or CPE or surgical site infection* or surgical wound infection* or SSI or SSIs or ventilator-associated pneumonia or VAP or ventilator-associated event* or VAE or (central line* adj3 infection*) or (catheter* adj3 infection*) or CLABSI or (urinary tract infection* adj3 catheter*) or CAUTI or CAUTIs or UTI or UTIs or antimicrobial resist* or microbial resist* or ARO or AROs or nosocomial or healthcare-acquired or healthcare-associated or health care-acquired or health care-associated or hospital-acquired or hospital-associated or HAI or HAIs).ti.	38072
3	(clostridium difficile* or "c. diff" or "c. difficile" or CDI or CDAD or methicillin-resistant staphylococcus aureus or MRSA or vancomycin-resistant enterococc* or VRE or carbapenemase-producing enterobacteriaceae or CPE or surgical site infection* or surgical wound infection* or SSI or SSIs or ventilator-associated pneumonia or VAP or ventilator-associated event* or VAE or (central line* adj3 infection*) or (catheter* adj3 infection*) or CLABSI or (urinary tract infection* adj3 catheter*) or CAUTI or CAUTIs or UTI or UTIs or antimicrobial resist* or microbial resist* or ARO or AROs or nosocomial or healthcare-acquired or healthcare-associated or health care-acquired or health care-associated or hospital-acquired or hospital-associated or HAI or HAIs).ab. /freq=3	31632
4	exp health facilities/ or cross infection/	620702
5	(hospital* or long-term care* or ((health* or medical or care or nursing or tertiary or mental health or rehab*) adj3 (facility or facilities or centre or center or setting* or home))).ti.	275118
6	(hospital* or long-term care* or ((health* or medical or care or nursing or tertiary or mental health or rehab*) adj3 (facility or facilities or centre or center or setting* or home))).ab. /freq=3	144624
7	1 or 2 or 3	151363
8	4 or 5 or 6	804505
9	7 and 8	55064
10	Population Surveillance/mt, st [Methods, Standards]	10081
11	Public Health Surveillance/	155
12	Sentinel Surveillance/	4857
13	(method* or instrument* or standard* or trend* or statistics* or organization).mp.	5048691
14	epidemiologic methods/ or contact tracing/ or data collection/ or epidemiological monitoring/ or exp statistics as topic/ or biometry/ or exp cluster analysis/ or exp models, statistical/ or exp probability/ or exp regression analysis/ or exp "sensitivity and specificity"/ or exp spatial analysis/ or exp stochastic processes/ or exp survival analysis/ or epidemiologic study characteristics as topic/	2120275
15	12 and 13	2044
16	10 or 11 or 12	15001
17	14 and 16	5610
18	13 and 16	7793
19	17 or 18	9908

Database: Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations and Ovid MEDLINE(R) 1946 to Present		
#	**Searches**	**Results**
20	7 and 19	753
21	9 and 14	13342
22	21 and surveillance.mp.	2146
23	22 and (system or database).mp.	531
24	20 or 23	1168
25	limit 24 to (english language and yr="2005 -Current")	705
26	from 25 keep 3-4, 6-7, 12, 14, 16, 19...	52
27	from 25 keep 121, 124-126, 128-129, 131, 133, 135...	111
28	from 25 keep 429, 446-449, 451-452, 460, 464, 479...	61
29	26 or 27 or 28	224
30	remove duplicates from 29	212

MORBIDITY/MORTALITY OF HEALTHCARE-ASSOCIATED INFECTIONS (ALL STUDY TYPES)

Database: Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations and Ovid MEDLINE(R) 1946 to Present		
#	**Searches**	**Results**
1	exp *morbidity/ or exp *mortality/ or exp *incidence/ or exp *prevalence/ or *epidemiology/ or *clostridium difficile/ep, mo, sn, td or *methicillin-resistant staphylococcus aureus/ep, mo, sn, td or *vancomycin resistance/ep, mo, sn, td or (exp *enterococcus/ep, mo, sn, td and vancomycin/) or (exp enterococcus/ep, mo, sn, td and *vancomycin/) or (*carbapenems/ and (enterobacteriaceae/ep, mo, sn, td or enterobacteriaceae infections/ep, mo, sn, td)) or (carbapenems/ and (*enterobacteriaceae/ep, mo, sn, td or *enterobacteriaceae infections/ep, mo, sn, td)) or *surgical wound infection/ep, mo, sn, td or *catheter-related infections/ep, mo, sn, td or *pneumonia, ventilator-associated/ep, mo, sn, td or *urinary tract infections/ep, mo, sn, td or *cross infection/ep, mo, sn, td	72939
2	(morbidity or mortality or incidence or prevalence or epidemiology).ti.	290937
3	(morbidity or mortality or incidence or prevalence or epidemiology).ab. /freq=3	286594
4	2 or 3	474965
5	limit 4 to ("in data review" or in process or "pubmed not medline")	27083
6	1 or 5	100022
7	*clostridium difficile/ or *methicillin-resistant staphylococcus aureus/ or *vancomycin resistance/ or (exp *enterococcus/ and vancomycin/) or (exp enterococcus/ and *vancomycin/) or (carbapenems/ and (*enterobacteriaceae/ or *enterobacteriaceae infections/)) or (*carbapenems/ and (enterobacteriaceae/ or enterobacteriaceae infections/)) or *surgical wound infection/ or *catheterization, central venous/ or *catheter-related infections/ or *catheters, indwelling/ae, mi or *pneumonia, ventilator-associated/ or exp *ventilators, mechanical/ae, mi or *urinary catheterization/ae or *urinary tract infections/ or *cross infection/	91897
8	(clostridium difficile* or "c. diff" or "c. difficile" or CDI or CDAD or methicillin-resistant staphylococcus aureus or MRSA or vancomycin-resistant enterococc* or VRE or carbapenemase-producing enterobacteriaceae or CPE or surgical site infection* or surgical wound infection* or SSI or SSIs or ventilator-associated pneumonia or VAP or ventilator-associated event* or VAE or (central line* adj3 infection*) or (catheter* adj3 infection*) or CLABSI or (urinary tract infection* adj3 catheter*) or CAUTI or CAUTIs or UTI or UTIs or antimicrobial resist* or microbial resist* or ARO or AROs or nosocomial or healthcare-acquired or healthcare-associated or health care-acquired or health care-associated or hospital-acquired or hospital-associated or HAI or HAIs).ti.	37944
9	(clostridium difficile* or "c. diff" or "c. difficile" or CDI or CDAD or methicillin-resistant staphylococcus aureus or MRSA or vancomycin-resistant enterococc* or VRE or carbapenemase-producing enterobacteriaceae or CPE or surgical site infection* or surgical wound infection* or SSI or SSIs or ventilator-associated pneumonia or VAP or ventilator-associated event* or VAE or (central line* adj3 infection*) or (catheter* adj3 infection*) or CLABSI or (urinary tract infection* adj3 catheter*) or CAUTI or CAUTIs or UTI or UTIs or antimicrobial resist* or microbial resist* or ARO or AROs or nosocomial or healthcare-acquired or healthcare-associated or health care-acquired or health care-associated or hospital-acquired or hospital-associated or HAI or HAIs).ab. /freq=3	31493
10	8 or 9	51903
11	limit 10 to ("in data review" or in process or "pubmed not medline")	3192
12	7 or 11	95089
13	exp health facilities/ or cross infection/	619613
14	(hospital* or long-term care* or ((health* or medical or care or nursing or tertiary or mental health or rehab*) adj3 (facility or facilities or centre or center or setting* or home))).ti.	274581
15	(hospital* or long-term care* or ((health* or medical or care or nursing or tertiary or mental health or rehab*) adj3 (facility or facilities or centre or center or setting* or home))).ab. /freq=3	144136

Database: Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations and Ovid MEDLINE(R) 1946 to Present		
#	**Searches**	**Results**
16	13 or 14 or 15	802962
17	6 and 12 and 16	9156
18	limit 17 to yr="2011 -Current"	1531
19	public health surveillance/ or population surveillance/ or biosurveillance/ or sentinel surveillance/ or public health informatics/ or data collection/mt	62320
20	(surveillance or monitor* or detect* or track* or threshold* or baseline* or endemic* or benchmark* or case finding or (public adj3 report*) or early warning or syndromic* or data mining or (data adj3 collect*) or sentinel event*).ti.	426823
21	(surveillance or monitor* or detect* or track* or threshold* or baseline* or endemic* or benchmark* or case finding or (public adj3 report*) or early warning or syndromic* or data mining or (data adj3 collect*) or sentinel event*).ab. /freq=3	384510
22	20 or 21	687293
23	limit 22 to ("in data review" or in process or "pubmed not medline")	48403
24	19 or 23	110723
25	clostridium difficile/ or methicillin-resistant staphylococcus aureus/ or vancomycin resistance/ or (exp enterococcus/ and vancomycin/) or (carbapenems/ and (enterobacteriaceae/ or enterobacteriaceae infections/)) or surgical wound infection/ or catheterization, central venous/ or catheter-related infections/ or catheters, indwelling/ae or catheters, indwelling/mi or pneumonia, ventilator-associated/ or exp ventilators, mechanical/mi or exp ventilators, mechanical/ae or urinary catheterization/ae or urinary tract infections/ or cross infection/	131111
26	(clostridium difficile* or "c. diff" or "c. difficile" or CDI or CDAD or methicillin-resistant staphylococcus aureus or MRSA or vancomycin-resistant enterococc* or VRE or carbapenemase-producing enterobacteriaceae or CPE or surgical site infection* or surgical wound infection* or SSI or SSIs or ventilator-associated pneumonia or VAP or ventilator-associated event* or VAE or (central line* adj3 infection*) or (catheter* adj3 infection*) or CLABSI or (urinary tract infection* adj3 catheter*) or CAUTI or CAUTIs or UTI or UTIs or antimicrobial resist* or microbial resist* or ARO or AROs or nosocomial or healthcare-acquired or healthcare-associated or health care-acquired or health care-associated or hospital-acquired or hospital-associated or HAI or HAIs).ti.	37944
27	(clostridium difficile* or "c. diff" or "c. difficile" or CDI or CDAD or methicillin-resistant staphylococcus aureus or MRSA or vancomycin-resistant enterococc* or VRE or carbapenemase-producing enterobacteriaceae or CPE or surgical site infection* or surgical wound infection* or SSI or SSIs or ventilator-associated pneumonia or VAP or ventilator-associated event* or VAE or (central line* adj3 infection*) or (catheter* adj3 infection*) or CLABSI or (urinary tract infection* adj3 catheter*) or CAUTI or CAUTIs or UTI or UTIs or antimicrobial resist* or microbial resist* or ARO or AROs or nosocomial or healthcare-acquired or healthcare-associated or health care-acquired or health care-associated or hospital-acquired or hospital-associated or HAI or HAIs).ab. /freq=3	31493
28	26 or 27	51903
29	limit 28 to ("in data review" or in process or "pubmed not medline")	3192
30	25 or 29	134303
31	exp health facilities/ or cross infection/	619613
32	(hospital* or long-term care* or ((health* or medical or care or nursing or tertiary or mental health or rehab*) adj3 (facility or facilities or centre or center or setting* or home))).ti.	274581
33	(hospital* or long-term care* or ((health* or medical or care or nursing or tertiary or mental health or rehab*) adj3 (facility or facilities or centre or center or setting* or home))).ab. /freq=3	144136

Database: Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations and Ovid MEDLINE(R) 1946 to Present		
#	**Searches**	**Results**
34	31 or 32 or 33	802962
35	24 and 30 and 34	2222
36	limit 35 to yr="2011 -Current"	359
37	18 not 36	1365

Database: Embase 1996 to 2013 Week 28		
#	**Searches**	**Results**
1	exp *epidemiology/ or exp *incidence/ or exp *prevalence/ or exp *epidemiological data/ or exp *morbidity/ or exp *mortality/ or *epidemiological monitoring/	150431
2	(morbidity or mortality or incidence or prevalence or epidemiology).ti,sh.	990834
3	(morbidity or mortality or incidence or prevalence or epidemiology).ab. /freq=3	297729
4	1 or 2 or 3	1109677
5	*clostridium difficile/ or *cross infection/ or *clostridium difficile infection/ or *methicillin resistant staphylococcus aureus/ or *vancomycin resistant staphylococcus aureus/ or *vancomycin resistant enterococcus/ or *vancomycin intermediate staphylococcus aureus/ or *vancomycin susceptible staphylococcus aureus/ or (*carbapenemase/ and (enterobacteriaceae infection/ or enterobacteriaceae/)) or (carbapenemase/ and (*enterobacteriaceae infection/ or *enterobacteriaceae/)) or *surgical infection/ or *urinary tract infection/ or *catheter infection/ or *hospital infection/ or *ventilator associated pneumonia/ or ((*ventilated patient/ or *ventilator/) and infection/) or ((ventilated patient/ or ventilator/) and *infection/) or *antibiotic resistance/ or *cross infection/ or exp *ventilator/ or *central venous catheterization/ or (*urinary tract infection/ and catheter/) or (urinary tract infection/ and *catheter/) or (*urinary catheter/ and infection/) or (*urinary catheter/ and *infection/)	78154
6	(clostridium difficile* or "c. diff" or "c. difficile" or CDI or CDAD or methicillin-resistant staphylococcus aureus or MRSA or vancomycin-resistant enterococc* or VRE or carbapenemase-producing enterobacteriaceae or CPE or surgical site infection* or surgical wound infection* or SSI or SSIs or ventilator-associated pneumonia or VAP or ventilator-associated event* or VAE or (central line* adj3 infection*) or (catheter* adj3 infection*) or CLABSI or (urinary tract infection* adj3 catheter*) or CAUTI or CAUTIs or UTI or UTIs or antimicrobial resist* or microbial resist* or ARO or AROs or nosocomial or healthcare-acquired or healthcare-associated or health care-acquired or health care-associated or hospital-acquired or hospital-associated or HAI or HAIs).ti,sh.	65605
7	(clostridium difficile* or "c. diff" or "c. difficile" or CDI or CDAD or methicillin-resistant staphylococcus aureus or MRSA or vancomycin-resistant enterococc* or VRE or carbapenemase-producing enterobacteriaceae or CPE or surgical site infection* or surgical wound infection* or SSI or SSIs or ventilator-associated pneumonia or VAP or ventilator-associated event* or VAE or (central line* adj3 infection*) or (catheter* adj3 infection*) or CLABSI or (urinary tract infection* adj3 catheter*) or CAUTI or CAUTIs or UTI or UTIs or antimicrobial resist* or microbial resist* or ARO or AROs or nosocomial or healthcare-acquired or healthcare-associated or health care-acquired or health care-associated or hospital-acquired or hospital-associated or HAI or HAIs).ab. /freq=3	35302
8	5 or 6 or 7	115602
9	exp health care facility/ or cross infection/ or healthcare associated infection/ or hospital infection/	639652
10	(hospital* or long-term care* or ((health* or medical or care or nursing or tertiary or mental health or rehab*) adj3 (facility or facilities or centre or center or setting* or home))).ti,sh.	718503
11	(hospital* or long-term care* or ((health* or medical or care or nursing or tertiary or mental health or rehab*) adj3 (facility or facilities or centre or center or setting* or home))).ab. /freq=3	158813

Database: Embase 1996 to 2013 Week 28		
#	**Searches**	**Results**
12	9 or 10 or 11	1071849
13	4 and 8 and 12	16324
14	limit 13 to exclude medline journals	1448
15	limit 14 to yr="2011 -Current"	568
16	disease surveillance/ or sentinel surveillance/ or biosurveillance/ or medical informatics/	21848
17	(surveillance or monitor* or detect* or track* or threshold* or baseline* or endemic* or benchmark* or case finding or (public adj3 report*) or early warning or syndromic* or data mining or (data adj3 collect*) or sentinel event*).ti,sh.	386470
18	(surveillance or monitor* or detect* or track* or threshold* or baseline* or endemic* or benchmark* or case finding or (public adj3 report*) or early warning or syndromic* or data mining or (data adj3 collect*) or sentinel event*).ab. /freq=3	392368
19	16 or 17 or 18	664209
20	clostridium difficile/ or cross infection/ or clostridium difficile infection/ or methicillin resistant staphylococcus aureus/ or vancomycin resistant staphylococcus aureus/ or vancomycin resistant enterococcus/ or vancomycin intermediate staphylococcus aureus/ or vancomycin susceptible staphylococcus aureus/ or (carbapenemase/ and (enterobacteriaceae infection/ or enterobacteriaceae/)) or surgical infection/ or urinary tract infection/ or catheter infection/ or hospital infection/ or ventilator associated pneumonia/ or ((ventilated patient/ or ventilator/) and infection/) or antibiotic resistance/ or cross infection/ or exp ventilator/ or central venous catheterization/ or (urinary tract infection/ and catheter/) or (urinary catheter/ and infection/)	195707
21	(clostridium difficile* or "c. diff" or "c. difficile" or CDI or CDAD or methicillin-resistant staphylococcus aureus or MRSA or vancomycin-resistant enterococc* or VRE or carbapenemase-producing enterobacteriaceae or CPE or surgical site infection* or surgical wound infection* or SSI or SSIs or ventilator-associated pneumonia or VAP or ventilator-associated event* or VAE or (central line* adj3 infection*) or (catheter* adj3 infection*) or CLABSI or (urinary tract infection* adj3 catheter*) or CAUTI or CAUTIs or UTI or UTIs or antimicrobial resist* or microbial resist* or ARO or AROs or nosocomial or healthcare-acquired or healthcare-associated or health care-acquired or health care-associated or hospital-acquired or hospital-associated or HAI or HAIs).ti,sh.	65605
22	(clostridium difficile* or "c. diff" or "c. difficile" or CDI or CDAD or methicillin-resistant staphylococcus aureus or MRSA or vancomycin-resistant enterococc* or VRE or carbapenemase-producing enterobacteriaceae or CPE or surgical site infection* or surgical wound infection* or SSI or SSIs or ventilator-associated pneumonia or VAP or ventilator-associated event* or VAE or (central line* adj3 infection*) or (catheter* adj3 infection*) or CLABSI or (urinary tract infection* adj3 catheter*) or CAUTI or CAUTIs or UTI or UTIs or antimicrobial resist* or microbial resist* or ARO or AROs or nosocomial or healthcare-acquired or healthcare-associated or health care-acquired or health care-associated or hospital-acquired or hospital-associated or HAI or HAIs).ab. /freq=3	35302
23	20 or 21 or 22	207335
24	exp health care facility/ or cross infection/ or healthcare associated infection/ or hospital infection/	639652
25	(hospital* or long-term care* or ((health* or medical or care or nursing or tertiary or mental health or rehab*) adj3 (facility or facilities or centre or center or setting* or home))).ti,sh.	718503
26	(hospital* or long-term care* or ((health* or medical or care or nursing or tertiary or mental health or rehab*) adj3 (facility or facilities or centre or center or setting* or home))).ab. /freq=3	158813
27	24 or 25 or 26	1071849
28	19 and 23 and 27	7779

Database: Embase 1996 to 2013 Week 28		
#	**Searches**	**Results**
29	limit 28 to exclude medline journals	733
30	limit 29 to yr="2011 -Current"	321
31	15 not 30	454

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